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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

PRELIMINARY REPORT

ON

ARTESIAN BASINS

IN

SOUTHWESTERN IDAHO AND SOUTHEASTERN OREGON

BY

ISRAEL C. RUSSELL

WASHINGTON
GOVERNMENT PRINTING OFFICE
1903

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, D. C., December 2, 1902.

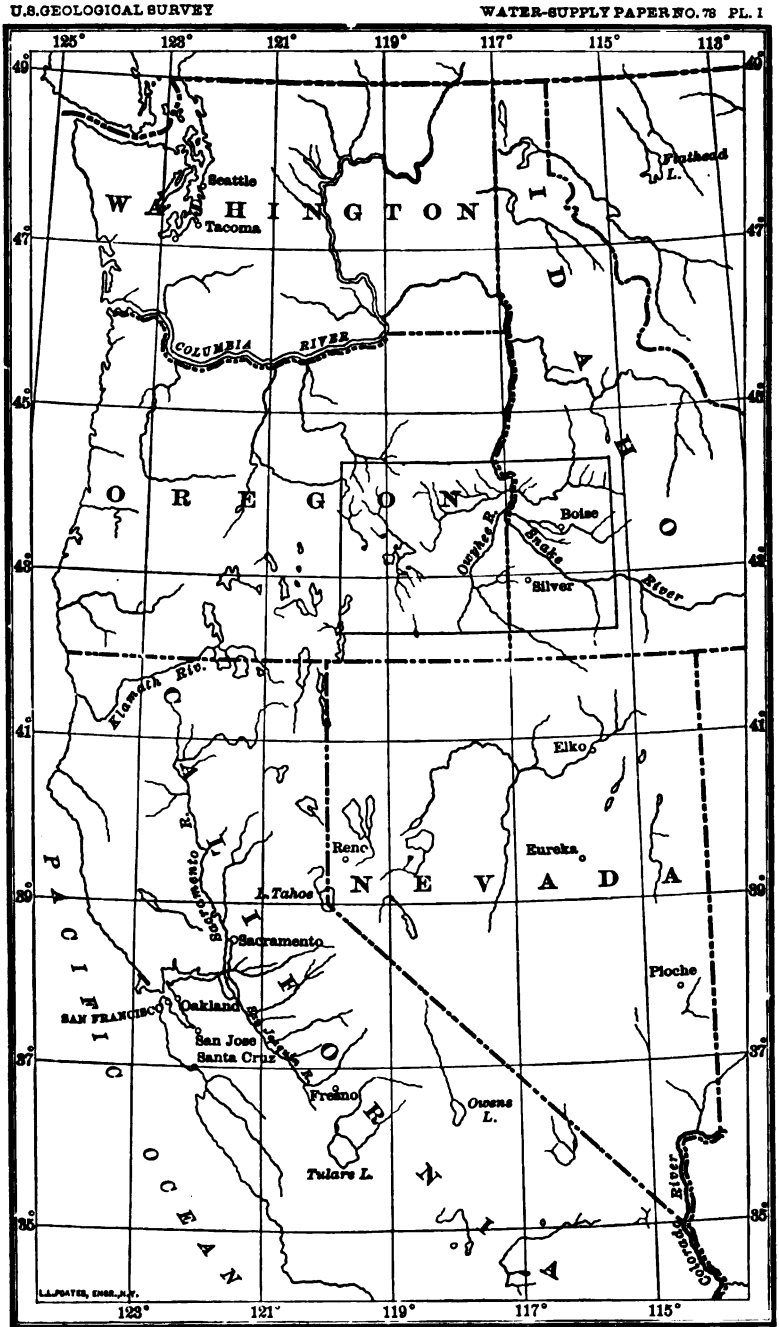
SIR: I have the honor to transmit herewith a manuscript prepared by Prof. Israel C. Russell, and to request that it be printed as one of the series of Water-Supply and Irrigation Papers. The paper relates to work carried on by Professor Russell during the summers of 1901 and 1902, and contains a description of the geologic structure of southwestern Idaho and southeastern Oregon, with special reference to the occurrence of underground waters. The artesian basins are described as far as these are known, and facts are assembled as to the probabilities of obtaining deep or flowing wells.

The information has particular value at this time, when great interest is being displayed in the reclamation of the arid lands. All facts which assist in procuring water are eagerly sought, and the data collected by Professor Russell are particularly important in the development of a large extent of vacant public land.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.



MAP SHOWING POSITION OF AREA UNDER DISCUSSION

Scale

100 50 0 100 200 300 miles

PRELIMINARY REPORT ON ARTESIAN BASINS IN SOUTHWESTERN IDAHO AND SOUTHEASTERN OREGON.

By ISRAEL C. RUSSELL.

INTRODUCTION.

During the summer of 1901 I made a geological reconnaissance in southern Idaho which covered, in a general way, the region embraced in the Snake River Plains from the boundary between Ada and Elmore counties eastward to Blackfoot.[a] The studies thus begun were continued in the summer of 1902, when parts of Canyon and Owyhee counties, Idaho, and of Malheur and Harney counties, Oreg., were examined. The route traversed during the second reconnaissance followed Snake River from Guffey northwestward to the mouth of Owyhee River, in Idaho, and thence through Vale, Westfall, Beulah, Drewsey, Harney, Burns, Narrows, Diamond, Smith, Mule, Alvord Valley, Jordan Valley, etc., in Oregon, to Rockville, on the west border of Owyhee County, Idaho. From Rockville the return to Boise was by way of Caldwell and Nampa. The route followed was chosen for the purpose of passing through the greatest number of valleys where artesian conditions might most reasonably be expected to exist and where the largest areas of good land are available for agriculture.

Each of the journeys referred to above was a rapid reconnaissance, having for its principal object the discovery of localities where flowing water can be obtained by drilling wells. In addition to gathering facts bearing on the question of an artesian water supply, as much attention as the time available would permit was given to the study of the general geology of the country traversed, the surface water supply, soil conditions, etc. The results of my examinations may, then, be divided into two parts—namely, that pertaining directly to artesian basins and that relating to geological history, topographical development, etc. As the search for artesian basins, especially during the journey made in 1902, was far more successful than I had hoped, it

[a] A report on this reconnaissance, entitled Geology and Water Resources of the Snake River Plains of Idaho, has been published as Bulletin No. 199 by the United States Geological Survey. A copy of this report may be had without charge by applying to the Director of the United States Geological Survey, Washington, D. C.

seems advisable to present a preliminary report, with the view of giving early information concerning the artesian basins to the people living in the region examined and later to prepare a more definite record of the geological and geographical facts observed.

During the reconnaissance of 1901 it was found that the geological conditions in the Snake River Canyon from near Glenns Ferry westward to the boundary between Elmore and Ada counties and in Bruneau and Little valleys are such that a surface flow of water can reasonably be expected where the surface elevation is not too great if wells are drilled to the proper depth. The artesian basin crossed by the portion of Snake River just mentioned was for convenience named the Lewis artesian basin, but its extension west of the boundary between Elmore and Ada counties was not examined. The western portion of the basin was made the first subject of study during the following field season, and, as will be stated later, it was found to reach westward to beyond the Idaho-Oregon boundary.

The reconnaissance in southeastern Oregon showed that if wells are properly drilled, a surface flow of water may reasonably be expected in at least three separate valleys in addition to the basin which is crossed by Snake River. These are Otis Valley, situated about 6 miles north of Drewsey; the broad valley in which Malheur and Harney lakes are situated, known in part as Harney Valley; and Whitehorse Valley, situated about 10 miles east of the higher portion of Stein Mountain. The basins in which these valleys are situated will be termed in this report the Otis artesian basin, the Harney artesian basin, and the Whitehorse artesian basin, respectively.

Before presenting the facts which are the basis of the conclusion that in each of the basins just named a surface flow of water can be had by drilling, it will, I think, be of assistance to review briefly the leading conditions governing the flow of artesian wells.

CONDITIONS ON WHICH THE FLOW OF ARTESIAN WELLS DEPENDS.

The term artesian well, as commonly employed, signifies a well which overflows upon the surface. The leading conditions favoring the rise and overflow of water from wells may perhaps be best indicated by describing the essential features of a typical artesian basin of the simplest character.

In what is properly termed an artesian basin, the layers of rock are bent downward, so as to resemble a pile of shallow plate-shaped dishes, placed one within another. One or more of the beds of rock is porous and allows water, supplied by rain on its upturned and exposed margin, to percolate into it. Above and below the water-charged layer are close-textured beds, like clay, which prevent the escape of the water in the bed between them. The leading conditions

which characterize artesian basins will be reproduced on a small scale if one pan is placed within another, and the two are separated by a layer of sand, and the spaces between the sand grains are filled with water. If a hole is drilled in the bottom of the uppermost pan, water will rise from below and overflow until the level of the water in each pan is the same. This is illustrated by the following cross section (fig. 1), which represents two pans, with a layer of sand between them, as they would appear if cut across and one-half removed. The pans in such an experiment represent the compact or impervious layers, and the sand the porous or pervious bed, in an artesian basin.

FIG. 1.—Cross section of two dishes with layer of sand between; to illustrate the leading essential features of an artesian basin.

In the following diagram (fig. 2) an ideal cross section is presented through an artesian basin which may be assumed to be 50 or more miles in diameter. The rocks are in layers or strata, and their combined thickness, we will assume, is 1,000 feet. A cross section taken in any direction through the pile of saucer-shaped beds (as is the case with the experiment with the pans referred to above) would be essentially the same. In the diagram (fig. 2) B and C represent compact and impervious beds, such as clay or shale; and A represents a porous bed, such as sand, open-textured sandstone, or fissured and broken rock. The beds, it will be noted, are depressed in their central parts, but about their edges come to the surface. Under these conditions water falling as rain on the exposed margin of the pervious bed and the water from streams, etc., would percolate into it until it was water filled. If, now, a hole drilled in the central part of the

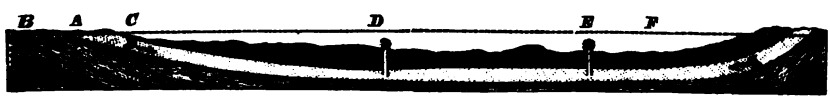


FIG. 2.—Ideal section illustrating the chief conditions requisite to artesian wells.

basin, as at D or E, reaches the pervious bed the pressure of water at a higher level will cause the water in the well to rise and overflow at the surface, and a flowing artesian well will result.

If, in the case just cited, no additional water should come to the exposed margin of the pervious bed, the well drilled at D or E would decrease in volume and finally cease to flow when the water in the porous bed, or so-called reservoir, was lowered so as to be on a level with the surface at the localities referred to. If, on the other hand, rain falls on the exposed margin of the pervious layer, or streams bring water to it, a continuous discharge from the well would result; as will be seen, one well in an artesian basin might be conspicuously

successful, while many wells might permit of such a freedom of escape of the water in a pervious bed as to practically ruin all of them.

In the illustration just presented, but one pervious bed was considered. In nature several such beds may be present in a single artesian basin, and several wells, drilled to different depths, might be successful, each well being supplied by a different pervious bed.

The height to which the water will rise above the surface opening of an artesian well depends on the height of the water in the raised border of the water-charged bed from which it derives its supply. For example, in fig. 2 the lowest point in the rim of the water-charged bed is at A, and if the pipe in the well drilled at D or E be carried up into the air and the end not closed, the water will rise in it until it reaches the level of A. The height to which the water will rise in an open tube attached to the surface opening of an artesian well is termed the artesian head. At all points within an artesian basin below the level of the artesian head water may be expected to rise to the surface and overflow when a well is drilled and properly cased. But if the surface of the ground is above the horizon of the outcrop of water-bearing bed, the pressure on the water will not be sufficient to force it to the surface, even if a drill hole is put down and properly cased. The height of the surface within an artesian basin may thus furnish the controlling condition on which success in searching for artesian water would depend. For this reason the pioneer well in an artesian basin should evidently be drilled at the lowest available locality in order to determine the artesian head. In making this test the bottom of the casing in the well should be just above the water-bearing stratum and securely packed on the outside so as to prevent leakage. If a well has a surface flow the height to which the water will rise above the ground may be learned by attaching a flexible hose pipe, or, in fact, any kind of a tube, to the upper end of the casing of the well and carrying it up a ladder or trestle until the water stands at the upper end, but does not overflow.[a] When two or more water-charged layers are present in an artesian basin, wells obtaining water from different layers may have different artesian heads.

Another necessary surface condition in reference to most artesian basins is that the margins of the porous beds shall rise to the surface and be exposed, so as to become charged with water from rain, melting snow, streams, etc. The amount of precipitation is also an important factor, especially in reference to the number of wells that may advantageously be put down in an artesian basin; but even in regions having an arid climate the porous beds beneath the surface so situated as to receive water at their edges, and from which its escape is prevented, will be found to be water charged.

As the pervious beds in an artesian basin commonly descend to a

[a] Practical suggestions in this connection are presented in the papers No. 3 and No. 4 in the list at the end of this report.

considerable depth below the earth's surface, the water which escapes from them when drill holes are put down is usually warmer than the water in neighboring dug wells. The reason for this is that the temperature of the earth increases with depth below its surface, as is discussed below. The temperature of water in a pervious bed is therefore regulated by the depth of the bed below the surface, and several flowing wells drilled in the central part of a basin should yield water with essentially the same temperature.

In the case of artesian basins generally, the water supply is furnished by rain and streams and enters the pervious beds at their outcrops—that is, the water descends into the pervious beds from above. There are instances, however, in which the water rises from below. If a basin exists, as already explained, water may be supplied to the pervious beds either by the upward leakage of a lower pervious bed, or, as is illustrated in the following diagram, by fissures in the rocks beneath.

The water which rises through deep fissures in the earth's crust is commonly hot, and when it appears at the surface forms hot springs. In a case like that illustrated by fig. 3 the pervious bed is charged by

FIG. 3.—Ideal section of an artesian basin charged with water rising from below through a fissure.

water rising through the rocks beneath it, and artesian wells supplied by it would have a higher temperature than under normal conditions would be expected from their depth. More than this, several wells drilled in the central portion of a basin which is supplied in the manner just explained might vary greatly in temperature according to their distance from the subterranean source of supply, although deriving their water from the same pervious bed. The artesian head in the case just cited would depend on the height of the water stored in the pervious bed, but could not exceed the pressure on the incoming water from a deep source. Where there is a subterranean source of water supply for an artesian basin there is probably always an additional supply coming from above, so that both the pressure and temperature of the water obtained by drilling will be regulated by an adjustment between these two leading conditions.

There are other conditions than those just considered which permit a surface flow of water when wells are drilled, but so far as the artesian basins to be described later are concerned, it is unnecessary to consider them at this time.

Even when a well-defined artesian basin is present there may be qualifying or adverse conditions which will prevent a surface flow of

water where one might reasonably be expected. These "accidents," as they may perhaps be termed, are caused by the fact that sheets of rock which are open textured, and consequently pervious, in one portion may become close textured and practically impervious in another portion. Also, an impervious bed may be fractured so as to allow the water to escape. In Idaho and Oregon the rocks which are bent so as to form basins are at times traversed by dikes; that is, more or less vertical sheets of rock formed by molten material forced upward into fissures from deep within the earth's crust, and cooling and hardening. There are still other locally adverse circumstances which may exist in even the best-defined artesian basins. These and other questions bearing on the success or failure of artesian wells have been discussed by several writers, and for a more complete and critical presentation of the subject than it is desirable to attempt at this time the reader is referred to the publications mentioned at the end of this report.

SURFACE INDICATIONS OF THE PRESENCE OF SUBSURFACE WATER UNDER PRESSURE.

The presence of artesian conditions is most frequently inferred from the structure of a basin, but confirmation of the supposition that water under pressure exists below the surface may frequently be had from the occurrence of warm springs. Such springs may also furnish evidence in reference to the depth to which a well should be drilled in order to penetrate the water-charged stratum.

The water which occurs in artesian basins has descended from the surface, and as the temperature of the earth increases with depth, the deeper the water has penetrated the rocks the higher will be its temperature. The increase in the temperature of the earth below a depth of about 50 feet in temperate regions is in general about 1° F. for each 60 feet, but there is considerable evidence for concluding that the rate of increase in southern Idaho and the adjacent part of Oregon is approximately 1° F. for each 45 feet in depth.[a] In temperate latitudes the increase in the temperature of the earth should be reckoned from a depth of 50 feet below the earth's surface, because the seasonal changes in temperature extend to that depth. At the horizon referred to there is a constant temperature which agrees with the mean annual temperature of the locality chosen. In the portions of Idaho and Oregon under consideration the mean annual temperature is approximately 50° F. In tropical countries the depth to which seasonal changes of temperature extend is less and in arctic regions much greater than that just stated. If, for example, a spring in the region referred to has a temperature of 65° F., or 15° above the temperature

[a] The facts on which this conclusion is based are recorded in Bull. U. S. Geol. Survey No. 199, 1902, pp. 173-174.

of the stratum of no seasonal variation, it would be safe to conclude that the water rises from a depth of at least 675 feet below that stratum or 725 feet below the surface. As the freedom of escape of the waters of springs is usually obstructed, some allowance must be made for its cooling as it rises, so that in the same case just cited 725 feet would indicate the minimum depth to which a drill hole would have to be extended with the hope of penetrating rocks in which water existed under sufficient pressure to cause it to rise to the surface.

In artesian basins there are apt to be localities where there is an escape of the water to the surface, so as to form springs. In such instances the springs usually flow throughout the year without appreciable changes in volume or in temperature, and the water is above the mean annual temperature of the locality where it reaches the surface. Where the structure of the rocks suggests that an artesian basin is present, the occurrence of warm springs within the basin is an assurance that water is present under sufficient pressure to force it to the surface in case wells are drilled. The warm springs referred to may be termed natural artesian wells, and their temperature indicates the depth of the water-charged bed below the surface, and the elevation of the locality where they occur gives a minimum measure of the height of the artesian head.

While warm springs (or those ranging in temperature from about 60° to 100° F.) situated within a region which has the structural features of an artesian basin may be taken as evidence of the presence of a water-charged layer which would supply flowing wells, a hot spring (or one having a temperature of more than 100°) is not so favorable an indication. Hot springs ordinarily rise from such a depth that even if they come from a well-defined water-charged layer it would be impracticable for most purposes for which artesian water is used to reach it by drilling. Although the conditions which lead to the occurrence of hot springs are not well understood, owing to the depth from which their waters rise, there are reasons for believing that they are frequently supplied by fissures that penetrate deep into the earth. The irregularities of fissures are such as to preclude prediction as to where they occur. In the case of every hot spring, however, there is a chance that if a well is drilled near it, even to a moderate depth, a flow of water will be secured, but in such instances the flow of water obtained should be classed as a "developed spring" rather than an artesian well. The fact, however, as previously explained, that water rising from a depth through fissures may charge the pervious beds in an artesian basin renders it evident that both warm and hot springs demand careful study in conducting a search for artesian water.

ROCKS OF THE REGION EXAMINED.

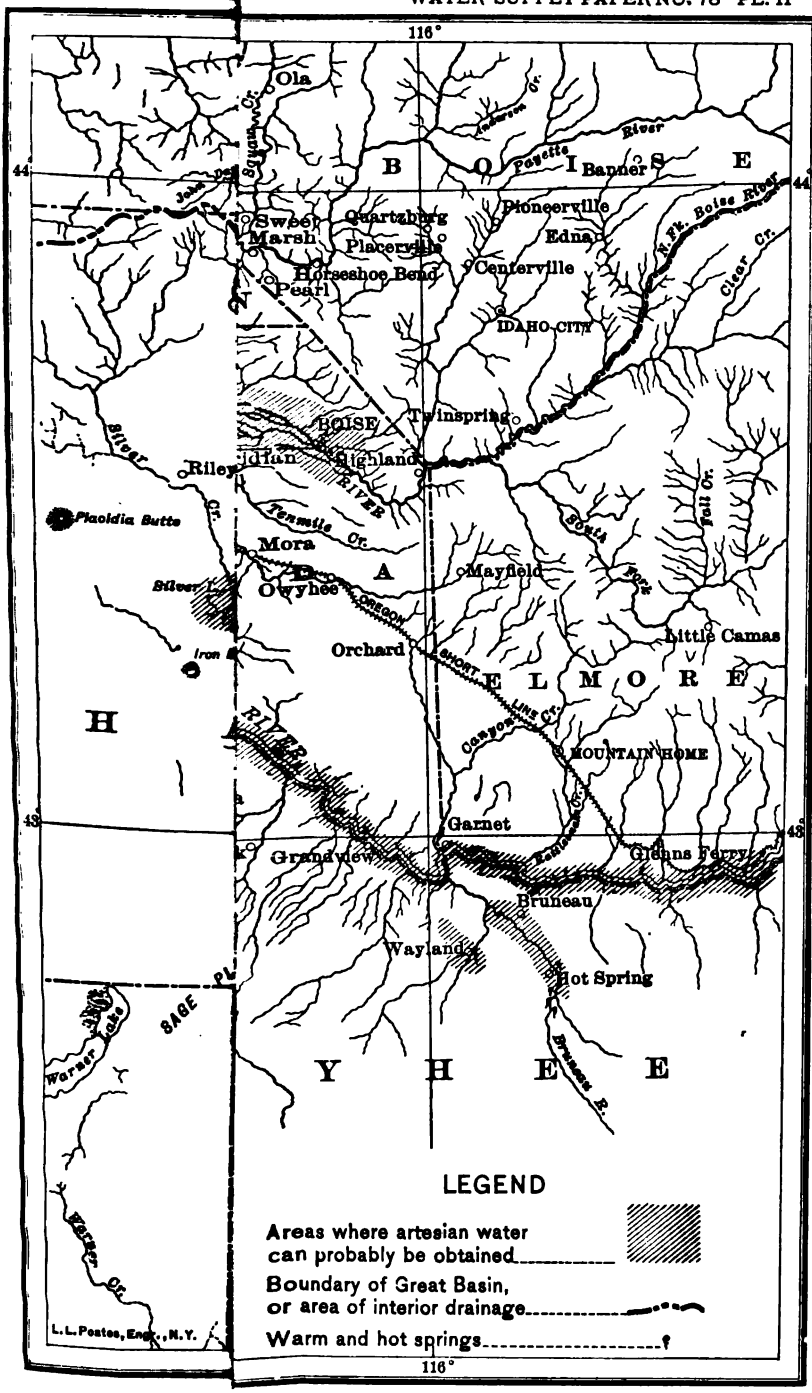
A classification of the most common rocks of southwestern Idaho and southeastern Oregon, sufficiently accurate for the present purpose, is as follows:

- Sedimentary rocks: Conglomerate, sandstone (in part hardened so as to form quartzite), shale, clay, sand, and gravel, together with beds of volanic dust and volcanic gravel or lapilli.
- Igneous rocks:
  - Volcanic rocks:
    - Lava flows: Basalt; Rhyolite.
    - Fragments blown out of volcanoes: Basaltic lapilli; Rhyolitic dust and tuff. (Also mentioned above as forming sedimentary beds.)
  - Plutonic rocks: The molten material like that extruded from volcanoes at the earth's surface, but which cooled below the surface in fissures, etc.

SEDIMENTARY ROCKS.

The stratified rocks of the region examined, or those composed of fragments of older rocks which have been spread out in layers or strata by the waters of lakes and streams, comprise conglomerate or pudding stone; sandstones; soft, highly calcareous, usually nearly white shales; loose gravel, sand, white volcanic dust; and dark, usually yellowish, volcanic gravel or lapilli. These beds were, for the most part, deposited in lakes during Tertiary time.

Examples of the conglomerate and sandstones referred to may be seen in the hills near where the Owyhee joins Snake River, in the isolated hills near Vale, and in the conspicuous bluffs to the southeast of Malheur and Harney lakes, as well as many other localities. These rocks are usually dark yellow, but occasionally, as near Narrows, are nearly white, and in some instances are sufficiently compact to be used for building stone. Associated with the layers of consolidated pebbles and sand just referred to, and having a wide extent in both Idaho and Oregon, are soft, unconsolidated light-colored shales and marls, and thick beds of nearly white sand and light-colored clay. Beds of this general nature, aggregating more than 1,000 feet in thickness, underlie Snake River Valley between Glenns Ferry and Weiser, and form the conspicuous white bluff along each side of that stream. Similar beds occur also in the lower portion of the valley of Malheur River and beneath the rim rocks of the canyons on the west slope of Stein Mountain. Light colored, and in part greenish shales, outcrop on the west side of Alvord Valley, where they pass beneath the sheets of basalt forming the bold eastern face of Stein Mountain. Fine exposures of rain-sculptured lacustral sediments, usually of a peculiar light-greenish tint, occur on the borders of Owyhee River near the mouth of Jordan Creek. Similar beds are present also in the


116°
Ola
Squaw Cr.
Jacksons Cr.
Payette River
B O I S E
Banner
Sweet
Marsh
Quartzburg
Placerville
Pioneerville
Edna
Centerville
Horseshoe Bend
Pearl
N. Fk. Boise River
Clear Cr.
IDAHO CITY
Twinspring
BOISE
Highland
Silver Cr.
Riley
Placoidia Butte
Tensmile Cr.
Mora
Mayfield
Owyhee
Silver
Oregon
Orchard
Iron
Little Camas
E L M O R E
H
Canyon
Lime Cr.
MOUNTAIN HOME
Garnet
Grandview
Glenns Ferry
Bruneau
Wayland
Hot Spring
Bruneau R.
SAGE
Warner Lake
Y H E E
Warner Cr.
L.L. Postes, Engr., N.Y.
116°
LEGEND
Areas where artesian water can probably be obtained
Boundary of Great Basin, or area of interior drainage
Warm and hot springs

mountains of Owyhee County, Idaho, and are an extension southward of the thick sediments exposed along Snake River. This same formation extends northward from Snake River and is exposed near Boise, and in the valley of Payette River. From its abundant outcrops along the last-named stream, it has been termed the Payette formation by Waldemar Lindgren.[a]

While the Payette formation has a wide extent in Oregon, and possibly reaches to John Day River, where other similar beds outcrop, it is not positive that all the exposures of similar material as far south as Harney and Silver lakes were deposited in the same lake basin. The lacustral sediments beneath the basalt of Stein Mountain have a thickness of fully 1,000 feet, and, as now seems probable, are older than the Payette formation.

Interbedded with the sandstone, shale, etc., of the formations just mentioned, and frequently forming a considerable and at times seemingly the major part of their thickness, are beds of exceedingly fine, white volcanic dust. This dust was blown out of volcanoes during violent eruptions, and falling in lakes, or being washed into them by streams, became interbedded with other sediments or intimately commingled with them. Pure white, stratified volcanic dust, from 10 to 20 feet or more thick, may be seen in the hills on the lower course of Owyhee River, a few miles south of Owyhee. It is also splendidly exposed near Beulah. Outcrops of material of the same nature, conspicuous on account of their whiteness, occur beneath the rim rock near Diamond, in the borders of the small valleys in the northern portion of Owyhee County, Idaho, as well as at a large number of localities in the bluffs bordering Snake River.

An interesting fact in connection with the stratified beds briefly described above is that they contain the bones of animals which are now extinct, but which lived in large numbers in and about the ancient lakes in which the sand, clay, volcanic dust, and other material now exposed and eroded into hills and valleys was deposited. Throughout these same beds, but most abundantly in the thinly laminated white silts and beds of fine volcanic dust, occur fossil leaves, and less commonly the fruits of plants. These plant remains differ from the vegetation living on the earth to-day, and reveal the nature of the luxuriant forests that flourished in the now arid portions of the far West during the Tertiary period of geological history. The fossil bones and impressions of leaves and fruits referred to, and also the shells of fresh-water mollusks frequently associated with them, are of great scientific interest, as they furnish evidence in regard to past climatic changes and the gradual evolution of life on the earth, and enable geologists to determine the age of the beds in which they occur.

[a] Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. III, pp. 632–634; Twentieth Ann. Rept., Pt. III, pp. 98–99; Geologic Folio No. 45.

The sedimentary beds to which attention has just been directed are in many instances open-textured and of such a nature that water will readily percolate through them, while in other instances they are of the consistency of clay and tend to retain water in the porous beds, if any is present, between them. These conditions indicate that wherever the sedimentary beds have been bent or displaced from their original horizontal position so as to form basins, there is a probability that flowing water may be obtained by drilling wells.

It is reasonable to assume that quartzite or granite is present beneath the Payette formation and associated volcanic rocks, throughout the Snake River Valley. The quartzite is usually a yellowish-white and excessively hard rock, and was orginally a sandstone, but has been altered or metamorphosed, so that the separate grains of quartz sand are no longer distinguishable. The granite is composed principally of conspicuous crystals of quartz, feldspar, and mica, as may be seen in the extensive outcrops in the mountains to the north of Boise, and is of deep-seated igneous origin. When either of these formations is encountered in drilling, the hope of obtaining flowing water by continuing to a greater depth had best be abandoned.

IGNEOUS ROCKS.

VOLCANIC ROCKS.

The rocks which came from volcanoes are by far the most conspicuous of any of the formations in southwest Idaho and the adjacent part of Oregon, and are no doubt of greater extent and thickness than the associated sedimentary beds. They may, with sufficient accuracy, be classified as basalt and rhyolite, but a critical study will no doubt show that what is here termed rhyolite in reality includes several rock species.

Both the basalt and the rhyolite present two conspicuously different phases, due to the manner in which the material composing them was spread out on the earth's surface. These rocks while molten were in part extruded by volcanoes so as to form sheets, which in many instances flowed far and wide over the surface of the land before cooling. In other instances the lava, while yet in the craters from which it came, cooled sufficiently to become rigid and was shattered by steam explosions, and the fragments thus produced were blown into the air and widely distributed through the action of the wind, etc., as sheets of volcanic dust, volcanic gravel, or lapilli and angular fragments, frequently of considerable size. The basalt was spread over the surface of the land, mostly in a molten and even highly fluid condition, and the beds of fragmental material produced were relatively small. The rhyolite, to a great extent, was shattered at the time it was erupted, and the resulting beds of fragments were probably of greater extent and thickness than the sheets of the same material which were

spread out as lava flows. This difference in the behavior of the volcanoes from which the comparatively fusible basalt was erupted and of the volcanoes from which the more refractory rhyolite was discharged is of much significance in reference to the nature of volcanoes, but can not be discussed at this time.

The basalt is a black, compact rock, but is frequently cellular and even scoriaceous on account of the presence in it of steam cavities, and in many localities is columnar. In the region under review it occurs in widely extended sheets, which in general vary in thickness from about 20 to 80 feet. Fine examples occur all along Snake River, but more especially on the northern side of its canyon, in the canyon of Bruneau River, and in the hills and mountains of Malheur and Harney counties, Oreg. The finest exposure of basalt in the region visited by me in 1902, if not the most remarkable in the world, is to be seen in Stein Mountain. The eastern slope of that splendid mountain is composed of the broken and eroded edges of sheets of basalt, which dip westward at an angle of 3° to 4° at the crest of the uplift, but flatten rapidly when traced westward, and present an aggregate thickness of not less than 5,000 feet. Between the sheets of basalt, as observed in at least eighteen instances, there are beds of coarse sandstone, varying in thickness from a few inches to 6 feet. Where the beds of sandstone occur the sheets of basalt are in general about 60 feet thick. From this and other similar evidence the total number of lava flows which occur at the locality referred to is estimated at between 80 and 100.

The widely extended sheets of basalt just referred to, like the sedimentary beds with which they are intimately associated—the sheets of basalt and the beds of sandstone, shale, clay, etc., in many instances alternating one with the other—are of ancient date, and belong principally to the Tertiary division of geological history.

Volcanic eruptions have occurred, however, at intervals from the time the oldest sheets of basalt were poured out in a molten condition down to almost the present day. Recent volcanoes, which discharged great quantities of basaltic lava in the condition both of lava sheets and of angular fragments, occur at three localities in southeastern Oregon. One of these is situated a few miles west of Diamond, Harney County, where there are craters that are built in part of scoria, lapilli, etc., and in part of lava sheets, and are surrounded by extensive lava flows. This group of small volcanoes may with propriety be named the Diamond craters. About 6 miles northeast of the former Bowdens post-office, in Malheur County, and approximately 18 miles south of Owyhee River where Jordan Creek joins it, there is an isolated crater of recent date, built almost entirely of congealed lava, which cooled about the opening in the earth from which it rose. About this Bowden crater, as it may be termed, is a recent lava flow which came from it and spread over at least 150 square miles of coun-

try. The most instructive as well as the latest of the three recent eruptions referred to occurs in the east-central part of Malheur County from 15 to 20 miles west of Jordan Valley, and the hills it built are here named the Jordan craters. The Cow Creek lakes owe their existence to the obstruction to the drainage caused by the extensive sheet of fresh black lava which came from the most northerly and most recent of Jordan craters. The rocks extruded from these recent volcanoes were spread over the surface both as lava flows and as sheets and piles of fragments, and serve in a most instructive manner to illustrate the mode of origin of the more ancient and far more extensive accumulation of similar rock.

The rhyolite, like the basalt, occurs both as massive sheets, which were poured out from volcanoes in a molten condition, and fragmental deposits, which also form well-defined beds. Of the beds originating in these two ways, the sheets of angular fragments, now in many instances firmly cemented and forming a rhyolitic tuff, are far more numerous and more extensive than the associated rhyolitic lava beds. The deposits of white volcanic dust described above as forming a part of the sedimentary formations are composed of the finest of the fragments blown into the air by the volcanoes from which came the material now forming the sheets of rhyolite and of rhyolitic tuff.

The compact, massive rhyolite is lighter colored than basalt, and in Idaho and Oregon is usually purplish on fresh surfaces, but weathers to a rich brown or red. It contains conspicuous crystals and grains of quartz, feldspar, and other minerals, and hence usually appears spotted. Frequently the crystals and grains referred to exhibit an arrangement such as would be produced by a flowing motion in the glassy base in which they are embedded.

The rhyolitic tuff is composed of angular fragments of the rock just described, which in most instances are firmly cemented so as to form sheets that are nearly, if not fully, as resistant to atmospheric conditions as the similar material which cooled from fusion without being shattered, as may frequently be seen in the rim rock on the sides of canyons and valleys.

Extensive exposures of rhyolite and of rhyolitic tuff occur in the mountains on the northeast side of Harney Valley, sometimes termed the Crow Creek Mountains. The conspicuous rim rocks on each side of Rattlesnake Creek, near Harney, are of rhyolitic tuff, while certain of the beds, usually cavernous on the weathered outcrops lower down in the walls of the same canyon, are of rhyolite which has a peculiar concentric or spherulitic structure. Again, in the bluffs of Silvies River, to the west of Burns, the edges of a thick sheet of compact tuff are well exposed, and similar rock has a wide distribution in the forest-covered mountains in which Silvies River rises. Other exposures of tuff and of compact rhyolite occur about Silver Lake, at Iron Mountain, and in the Mahogany Mountains. The conspicuous rim

rocks in the vicinity of Diamond are composed of tuff, and similar rock has a wide distribution in the hills near Smith and Mule.

An interesting fact in connection with the sheets of rhyolite and of rhyolitic tuff in southeastern Oregon is that they are younger than most of the basalt of the same region and overlie it. There have been eruptions of basalt, also, since the youngest observed sheet of rhyolite and of rhyolitic tuff was spread out.

The rhyolitic tuff is in many instances highly porous and permits the free percolation of water through it, but in other instances it is firmly cemented and probably nearly impervious. The compact rhyolite is to be classed, in most instances, as an impervious rock, although its weathered outcrops are at times conspicuously cellular. The presence of sheets of these rocks in an artesian basin, together with sheets of basalt and stratified sandstone, shales, clay, sand, etc., would tend to increase the variety among the strata, and in a general way, at least, be favorable to the storage of water under pressure.

PLUTONIC OR DEEP-SEATED IGNEOUS ROCKS.

The molten magmas which rise in volcanoes and in part overflow, so as to form lava sheets, also, in part, cool below the surface in the conduits of volcanoes and in fissures. Many distinctive features in the rocks produced from the same molten magma arise in this way, which it is unnecessary to consider at this time.

Both the basalt and the rhyolite, which occur in extensive sheets in Idaho and Oregon, came to the surface through openings, as fissures, for example, and below the present surface it is to be expected that there were many fissures in which molten rock has cooled, so as to form what are termed dikes. A few dikes were observed in the bold eastern face of Stein Mountain, and indicate that others may be present elsewhere. The dikes referred to are nearly vertical, vary in width 20 to 60 feet, and are horizontally columnar. As is well known, dikes have frequently led to the hardening of the walls of the fissures they occupy and for this and other reasons their presence in an artesian basin might introduce serious difficulties in the way of obtaining flowing wells. If in drilling a well, the locality chosen should chance to be directly above a dike, it is probable that the well would be a failure, even if the usually compact and hard rock of the dike could be penetrated. Where the country rock is concealed beneath deep sheets of soil, alluvial deposits, etc., it is frequently impossible to detect the presence of dikes in the rocks beneath the surface covering, unless they are encountered in drilling or making other excavations. So far as can now be judged, however, the dikes in the artesian basins described in this report are not numerous, and the chances of striking them in drilling are small. A greater danger lies in the fact that they may cut a pervious bed so as to prevent the percolation of water through it.

GEOLOGICAL STRUCTURE.

By geological structure is understood in part the positions occupied by stratified or bedded rocks in the earth's crust. For example, sandstone, shale, etc., originally laid down in horizontal sheets, are now found in many instances to be inclined or folded, and often occupy a vertical position.

The rocks, both sedimentary and volcanic, which underlie southwestern Idaho and southeastern Oregon, were at the time of their formation spread out in nearly horizontal layers, but subsequently they have been depressed in one locality and raised in another, and in certain instances crushed together so as to form great upward and downward folds. In other localities they have been broken along nearly vertical planes, and a portion of the strata on one side of the break has been upraised or depressed in reference to corresponding strata on the opposite side; that is, the beds have been faulted. Examples of gentle tilting of previously horizontal sheets of rocks throughout great areas are furnished in the broad Snake River Plains between Glenns Ferry and Owyhee. To the north of Snake River the rocks are now gently inclined upward to the north, but south of the river the same beds rise when followed southward, and in the Owyhee Mountains the strata are more than a thousand feet above the position they occupy beneath Snake River. This uptilting of stratified beds is well displayed in the hills near the point where Snake River first crosses the Idaho-Oregon boundary. These remnants of formerly much more extensive strata indicate not only the way in which once horizontal beds have been tilted, but bear evidence as to the great amount of denudation that has occurred throughout an extensive region.

Broad and comparatively gentle elevations and depressions of once horizontally stratified rocks occur also in other portions of the region examined; as, for example, in the neighborhood of Harney and Burns. The rocks beneath the extensive valley in which Malheur and Harney lakes are situated slope upward in the hills and mountains about the borders of the basin, as is well shown in the walls of the canyons on the west side of Stein Mountain, in the Crow Creek Mountains, on the border of the canyon of Rattlesnake River, in the hills west of Burns, and several other localities. In general, all about the Harney basin, as it is convenient to term the great depression in which Malheur and Harney lakes are situated, as well as in the country draining to them, the rocks are upraised. This basin, however, is not a simple saucer-shaped depression, but has irregularities, and is due to the association of several areas in which upheavals or depressions have occurred.

The broad, gentle undulations in the rocks just referred to, which in some instances have horizonital axes measuring a hundred or more miles, are promising structural features in reference to the hope of obtaining an artesian-water supply.

Of smaller size than the broad and usually somewhat indefinite swells and depressions referred to above are upward folds, or anticlines, and downward folds, or synclines. These are similar in shape and in the manner in which they are produced to the folds or corrugations that may be made by pushing one side of a pile of rugs toward its center; or, on a still smaller scale, by forcing together the sides of a pile of newspapers so as to compress them into folds. In the region under consideration there are several examples of such folds; but, as is commonly the case on all land areas, the relief produced in the manner referred to has been greatly modified by erosion. The upward folds particularly have been cut away, leaving for the most part only their basement portions.

A striking illustration of a great upward bend, involving bedded lava sheets having an aggregate thickness of fully 5,000 feet and a great but unknown thickness of stratified sedimentary deposits as well, is furnished by the north portion of Stein Mountain and the several parallel nearly north-south ridges to the east of it and north of Alvord Desert. The larger features of this rugged belt of country are due to the erosion of a great anticlinal fold, the longer axis of which trends about northeast and southwest. The hard layer of compact basalt in the truncated remnant of the fold now forms the sharp crested ridges to the east of Juniper and Mann lakes, which have a gentle surface slope on one side and a steep escarpment on the other.

A characteristic example of a broad downward fold or syncline may be seen from the summit of Stein Mountain on looking toward the southwest over the region drained by Donner and Blitzen River. The longer axis of this basin trends in a north-south direction and is inclined downward, or pitches, to the north.

Accompanying the bending of rocks so as to form corrugations, breaks sometimes occur, and the edges of the broken layers on the sides of the fracture are upheaved or depressed with reference to each other. In this and yet other ways what are termed "faults" are produced.

When the rocks have been broken and displaced or faulted, the conditions are not favorable for obtaining artesian water. Even if an artesian basin is present, the impervious beds, which would otherwise confine water under pressure, may be broken and permit the water to escape. In this connection it is to be noticed that hot springs are frequently situated on fault lines. In the case of the Stein Mountain fault, a spring with several surface openings having temperatures ranging from 168° to 177° F. occurs on the southwest side of Alvord Desert.

It is principally from the study of the structure of the rocks in any region that the presence of artesian basins is to be determined. The reason why structure may be considered as the controlling condition in this connection is because the other necessary conditions, such as the presence of pervious and impervious layers in a series of stratified

rocks, the presence of water in pervious beds, etc., are of common occurrence; while the requisite conditions for storing water beneath the earth's surface and under pressure are much less frequent, and it is these conditions which are dependent principally on the positions which the rocks occupy—that is, the geological structure. When a saucer-shaped basin is present, the chances are that the other necessary conditions will also exist.

ARTESIAN BASINS.

The four principal areas in southwest Idaho and southeast Oregon in which artesian water has already been discovered, or in which convincing evidence is found that it may be obtained, have already been referred to under the names of the Lewis, Otis, Harney, and Whitehorse artesian basins. Such facts as have been learned concerning each of these basins as are thought to be of immediate value to persons interested in the development of their artesian conditions are here presented.

LEWIS ARTESIAN BASIN.

The portion of this artesian basin in which flowing water may be obtained is situated along Snake River between Glenns Ferry and Weiser, and might with propriety have been named after it, except for the possibility that other artesian basins may be discovered in the extensive region it drains. Lewis, the less frequently used but more appropriate name of the Snake River, has therefore been selected as a convenient term by which to designate the artesian basin under consideration.

The rocks on each side of Snake or Lewis River from near the mouth of Kinghill Creek westward to beyond the Idaho-Oregon boundary are gently inclined or dip toward the canyon of that stream from each side. The inclination of the rocks is most readily seen on the south side of Snake River; as, for example, in the highlands to the east of Bruneau River, and in the hills near the mouth of Owyhee River, where the strata rise when traced southward at the rate of perhaps 100 feet to the mile. This rise, although gentle, is sufficient to carry the strata which underlie Snake River to an elevation of more than a thousand feet above its surface in the hills and mountains of Owyhee County. On the north side of Snake River the rocks are seemingly level, but, as nearly as can be judged, rise gradually to meet the mountains of older rock to the north of Mountain Home, Boise, etc. The inclinations of the rocks just referred to show that they have been bent into a broad trough-shaped depression, the longer axis of which bears about northwest and southeast, and is followed by the canyon of Snake River in a general way from Glenns Ferry to the Idaho-Oregon boundary. In certain localities, however, the axis of the fold is a mile or two north of the river.

On reaching Snake River, in 1901, I observed the general features pertaining to the dip of the rocks just referred to, and at once recognized the possibility of the presence of an artesian basin. Other conditions confirming the truth of this inference, such as the presence of warm and hot springs, were soon discovered, and the fact was learned that several successful artesian wells had already been drilled in Bruneau and Little valleys, thus demonstrating that water under pressure exists below the surface. In 1902 the portion of Snake River Valley lying west of the region traversed the previous year was examined, and the structural basin referred to was found to extend beyond the Idaho-Oregon boundary and to include a wide extent of territory in Oregon.

The eastern end of the Lewis artesian basin is for convenience considered to be near the eastern boundaries of Elmore and Owyhee counties, principally for the reasons that this is the eastern limit in the canyon of Snake River where land suitable for irrigation occurs below the artesian head of the basin as at present known, and also because sufficient study has not as yet been given to the region east of the counties mentioned to justify me in expressing an opinion in reference to the actual eastern extension of the basin in question.

The margin of the Lewis artesian basin can not yet be actually mapped, but within it is included, in a general way, the Snake River Plains in Elmore, Ada, and Canyon counties, and the country in Owyhee County which is drained by northward-flowing streams. In Oregon its boundary is still less definitely known, but it includes the greater part of the northern third of Malheur County. The position of the actual boundary of the basin, or the line from which the rocks begin to slope toward a central axis, is of much less practical moment, however, than the boundary of the country below the artesian head.

As will be stated below, the artesian head of the Lewis artesian basin has not been accurately determined, but provisionally it is taken at 2,500 feet above sea level. This is certainly a safe assumption, as flowing wells now discharge this water at that level, and others, as determined by a less accurate method of measurement, namely, the aneroid barometer, overflow at 2,700 feet above the sea. This indefiniteness is due to the fact that none of the wells in the basin are properly cased, and it was impracticable with the means at my disposal to make definite measurement of the water pressure. However, the area throughout the greater part of the Snake River Canyon or Valley, which is between an elevation of 2,500 and 2,700 feet, is comparatively small, and the extent of territory below the former level is probably more than sufficient to utilize all the artesian water that can be had within its boundary.

The tracing of the territory below the known artesian head in the portion of the Lewis artesian basin which is situated in Idaho is a simple matter, as most of it has been surveyed and accurate contour

maps are available. The maps referred to are published by the United States Geological Survey, and comprise the following sheets of the topographic atlas of the United States: Mountain Home, Bisuka, Boise, Silver City, Nampa, and Weiser.[a] By consulting these maps it will be seen that a large extent of territory adjacent to Snake and Boise rivers lies below the 2,500-foot contour. Practically all of the flat land favorable for agriculture adjacent to Snake River, between Glenns Ferry and the mouth of Boise River, lies below the horizon referred to. That is, the 2,500-foot contour marks, in general, the beginning of the abrupt slopes which rise from the flat lands bordering the river to the margin of the plateau above. In the region referred to, where the surface is less than 2,500 feet above the sea, wells put down to the requisite depth, which will be discussed later, should yield flowing water. A considerable extent of country about Nampa and Caldwell, much of the valley of Boise River, and of the Snake River Valley between the mouths of the Boise and Weiser, are also below the 2,500-foot contour, and so far as can now be judged, wells put down in this region should also yield an artesian flow.

There are no good maps of the region in Oregon embraced within the Lewis artesian basin, and it is impracticable to state at present where the plane of the assumed artesian head, 2,500 feet above the sea, intersects the surface. Much of the nearly level land that is otherwise favorable for agriculture adjacent to the west side of Snake River from where it first crosses the Idaho-Oregon boundary northward to the vicinity of Weiser, and an extensive tract in the lower 25 miles of the valley of Malheur River are certainly within the limit referred to, and careful tests of the artesian conditions should be made. A rough estimate of the extent of agricultural land in Idaho and Oregon that is within the Lewis artesian basin and below its known artesian head shows it to be not less than 1,000 square miles.

As the conclusions just presented will no doubt be considered too sanguine by many persons, I desire to indicate briefly the evidence, other than the geological structure, on which they are based, and at the same time to furnish data which will assist in the more complete development of the artesian conditions.

SPRINGS.

Within the Lewis artesian basin there are a number of warm and hot springs, which show that water under pressure exists below the surface.

Mountain Home.—About 3 miles east of Rattlesnake Creek, at the locality where "Old" Mountain Home was located, there is a fine spring, or group of springs, with a maximum temperature of 167° F.

[a] These maps, on a scale of about 2 miles to 1 inch, with a contour interval of 100 feet, each sheet including about 850 square miles, can be purchased of the United States Geological Survey for 5 cents each.

The surface level is about 3,550 feet. The water is of good quality, but is not now utilized except in a small way for bathing. No attempt has been made to develop the spring by boring, although good land occurs near at hand on which any water that might be obtained could be used for irrigating.

Boise.—Springs issue from sandstone of the Payette formation, 4½ miles east of Boise, at an elevation of about 2,750 feet. The water has a faint smell of sulphureted hydrogen, contains a small amount of mineral matter in solution, and varies in temperature from 125° F. to near the boiling point.

Salmon River.—A small spring on the left bank of Snake River, about 4 miles above the mouth of Salmon River, Cassia County, has a temperature of 131° F. Another hot spring occurs in the canyon of Salmon River, about 5 miles above its mouth.

Little Valley.—Near the head of Little Valley, Owyhee County, there are several warm springs and one small hot spring, temperature 101° F., which is now partially developed by drilling wells near it to a depth of 40 feet.

Bruneau Valley.—Near Hot Spring post-office there are several copious springs, with a temperature of 109° F. One of these has been developed by drilling a well near it to a depth of 240 feet. The well furnishes 7 gallons of water per minute.[a]

Walters Butte.—A copious spring about 1 mile west of Walters Butte, Canyon County, where the elevation is 2,340 feet, has a temperature of 67° F. This spring is very likely due to the leakage from water-bearing strata, and suggests that wells put down in its vicinity to a depth of about 350 or 400 feet would yield a surface flow of water. Near Walters Butte there is an area of about 4 square miles of favorable land that lies below the known artesian head of the basin in which it is situated.

Enterprise.—On the south side of Snake River, at Enterprise, Owyhee County, there is a spring issuing at an elevation of 2,220 feet, with a temperature of 128° F., which discharges approximately 7 cubic feet of water per second and is now utilized for bathing and for irrigating about 10 acres of land. The water rises where there is a thickness of nearly 1,000 feet of soft lake sediment (Payette formation) and, as its temperature indicates, comes from a depth of approximately 4,500 feet.

Sands.—From 2 to 3 miles west of Sands, in Owyhee County, and near the point where Poison Creek descends through a deep cleft in the upland and enters Snake River Valley, there are copious springs, with a temperature of about 100° F., which are used for irrigation. These springs rise where the surface level is approximately 2,450 feet, and may reasonably be supposed to be supplied by the leakage of porous

[a] Concerning the five localities mentioned above additional information is presented in Bull. U. S. Geol. Survey No. 199.

beds in the Payette formation. They occur within the Lewis artesian basin, nearly up to the known artesian head of that basin, and are a favorable indication that wells drilled in their vicinity to a depth of approximately 1,000 feet would prove successful, but from other evidence it is to be presumed that flowing water might be expected on drilling to a less depth. To the north of the conspicuous line of bluffs trending northwest and southeast and passing Sands on the south is a large tract of good land, embracing in fact something like 100 square miles, which is below the level of the springs just referred to, and where one is justified in assuming that artesian water can be had.

Owyhee Canyon.—In the canyon of the Owyhee, about 6 miles south of Owyhee post-office, there is a copious hot spring, which issues from openings in volcanic rock and has a temperature of about 115° F. But little irrigable land occurs near this spring, and for this reason an attempt to develop it and concentrate its flow would at present not be warranted.

Vale.—At Vale, on the east border of Malheur River, there is a spring with a temperature of 198½° F. Near at hand a well put down to a depth of 140 feet yields a strong flow of water with the same temperature. These springs are in a broad region underlain by the Payette formation, but it is presumed, are supplied by fissures. These springs rise at the west base of a prominent hill, composed in part of cemented gravel, and the manner in which they are depositing mineral matter suggests that the pebbles and sand in the hill were cemented by the same process. Other similar hills or buttes are situated a mile or two northward, and another is a conspicuous object about 5 miles farther north. Each of these exceptional features in the topography of the valley is due to the resistance offered to erosion by the hard beds they contain, and suggest that in each case hot springs rising through the Payette formation have led to a local hardening of its more porous strata and, in consequence, their preservation as erosion progressed. This suggestion was not tested by examining each of the hills referred to, but may be of interest to students of geology who visit them in the future, and in addition may be found to explain the manner in which hot springs sometimes occur in artesian basins, but do not appear to have any connection with neighboring artesian wells.

Westfall.—On the stage road between Vale and Westfall, in sec. 9, T. 18 S., R. 43 E., there is a spring with a temperature of 168° F. at an elevation by aneroid barometer of 2,400 feet. This discharges by estimate about 2 miners' (California) inches, or 100 cubic inches per second, but the total flow from the several small openings is probably greater than this. The waters have a slight odor of sulphureted hydrogen, and are depositing lime in the form of cellular calcareous tufa. The water is used for bathing, and in part is conducted to a house

through a pipe and used for cooking, etc. A small spring near at hand, supplied by percolation from the alluvial material in the bed of Bully Creek, has a temperature of 54° F.

The hot spring just mentioned is within the territory included in the Lewis artesian basin, and, judging from the approximate measures available, is below the artesian head of that basin, but owing to the high temperature of its waters and the consequent depth from which they rise, and the nature of the rocks in the vicinity, little if any significance in reference to the probability of obtaining artesian water in its neighborhood can be attached to it.

Beulah.—Small springs in the valley of Warm Creek, near Beulah, have a temperature of 185° F.

DRILLED WELLS.

In the portion of the Lewis artesian basin examined by me in 1901 it was found that several moderately deep borings had already been put down, several of which yielded a surface flow of water. Some account of the borings referred to was presented in my report for the year named,[a] but for the purpose of bringing together all the available evidence furnished by borings concerning water pressure, etc., within the Lewis artesian basin a brief account of those previously described is here inserted.

Boise.—To the north and east of Boise and within 2 miles of the city several flowing wells have been obtained by drilling in the Payette formation, and the water they supply is now utilized for city purposes. Boise is fortunate in possessing both cold and hot artesian wells. The following facts concerning them are compiled from a report on the geology of the Boise region of Waldemar Lindgren.[b]

The several cold artesian wells at Boise (temperature about 55° F.) are situated in the gulches north of the city and at an elevation of about 2,750 feet. They vary in depth from 400 to 609 feet, but since this information was obtained some of them have been deepened. The materials passed through in Hulls Gulch are sand and sandstone, 200 feet, and clayey beds, 200 feet, below which water was obtained. In the deepest well there are below the clay 40 feet of sand, 20 feet of clay, and 46 feet of solid basalt, below which clay occurs again. These wells yield from 40 to 250 gallons per minute, and their combined flow is stated to be about 670 gallons per minute. The water is stored in a covered reservoir and from there conducted into the city water mains.

Two wells drilled on the Davis ranch, in the next gulch north of Hulls Gulch, to a depth of 150 feet yield 40 gallons of water per

[a] Bull. U. S. Geol. Survey No. 199.

[b] Geologic Atlas U. S., folio 45, Boise, Idaho; published by the U. S. Geol. Survey and sold for 25 cents per copy.

minute. A well drilled to a depth of 400 feet in a ravine south of Hulls Gulch passed through clay and failed to reach water under pressure.

The hot artesian wells at Boise are situated two miles southeast of the city. Three of these, the water of which is piped to the city and extensively used for heating, baths, etc., have depths of 394, 404, and 455 feet. The character of the rocks penetrated is not definitely recorded, but it is stated that the drill, after passing through sandstone, penetrated several sheets of basalt, below which occurred red volcanic tuff or fragmental volcanic rock more or less thoroughly cemented and containing much black sand. The combined discharge of the three wells is 550 gallons a minute. The water is slightly charged with mineral matter in solution (about 300 parts in 1,000,000) and has a temperature of 170° F. The surface elevation is nearly 2,800 feet, and the water is under sufficient pressure to cause it to rise in a tube open at the top about 50 feet above the surface, or to an elevation of 2,850 feet above the sea. Several wells have been drilled on the United States military reservation a mile east of Boise, at least two of which discharge warm water. Their depths are 450 and 482 feet. The surface elevation is 2,850 feet. From the first mentioned a small flow of water with a temperature of from 75° to 140° F., increasing with depth, was obtained. The second gave a flow of about 35 gallons per minute, the water having a temperature of 90° F. These wells are located near a small tepid spring, and penetrated first 130 to 160 feet of sandstone, then 72 to 116 feet of hard, black lava (basalt), below which occurs a series 200 to 250 feet thick of clays and red basaltic tuff rich in magnetite (black sand) and sometimes containing also iron pyrites.

Other artesian wells in the neighborhood of Boise are briefly described in the Boise folio referred to above.

Both the cold and the hot artesian wells near Boise are in the Payette formation and associated and interbedded sheets of basalt which underlie the Snake River Plains. These same beds outcrop on the border of Snake River Canyon, and south of Snake River rise to an elevation of 4,000 feet or more in the Owyhee Mountains. These facts, together with the geographical position of the wells and the elevation at which they are located—that is, about 2,850 feet—render it at least possible that they belong to the Lewis artesian basin.

Bruneau Valley.—In the upper portion of Bruneau Valley there are three flowing wells, each 2½ inches in diameter, which, together with the numerous hot springs of the same region briefly described above, show that an abundance of water exists at a moderate depth and under sufficient pressure to cause it to rise to the surface if openings are provided.

On W. N. Roberson's ranch, about 2 miles north of Hot Spring

post-office and on the west side of the valley, a drilled well having a depth of 240 feet delivers about 7 gallons of water per minute, having a temperature of 109° F. This well is within a few feet of a large hot spring having the same temperature, the flow of which was not diminished when the well was drilled. The elevation of the surface at this point, by aneroid, is 2,750 feet. The section passed through, as reported from memory by Mr. Roberson, is as follows:

Section at Roberson's ranch.

	Feet.	Inches.
Light-colored sandy clay (Payette formation)	236	
Granular black layer, like basalt (volcanic lapilli)		10
Blue clay (Payette formation)	4	
Black lava	Several inches.	
Total depth, approximately	240	

The water is used for household purposes and for irrigation.

Nearly opposite the well just described, on the east side of the valley and at an elevation approximately 50 feet higher, a well drilled to a depth of 230 feet, on land belonging to Mr. A. H. Pence, gave a small surface flow.

On B. Whitson's ranch, on the eastern side of the valley, about 3 miles north of the two wells just mentioned, where the surface elevation is by aneroid 2,750 feet, a well 700 feet deep discharges about one-third cubic foot of water per second. The temperature is reported to be 90° F.

These three wells derive their water from different depths, and seem to indicate that water under pressure exists in at least three disconnected pervious layers, or else that a source of supply more deeply seated than has been reached by any of the drill holes yet made charges porous beds above it through fissures. The abundance of hot springs in the same vicinity apparently favors the latter hypothesis.

Little Valley.—Near the head of Little Valley, 9 miles west of Bruneau, there are five flowing wells, which range in depth from 150 to 215 feet, each drilled with a 2½-inch bit and poorly cased. The water is of good quality and has a temperature of about 67° F. The flow varies somewhat with seasonal changes, being greatest in winter and spring and least in summer and fall. In most of these wells the pipes have become clogged and the discharge is small. One of the stronger of the wells delivers in August a gallon of water in seven minutes, and is said to discharge about a gallon per minute in winter. Neighboring springs have various temperatures, ranging from 56° to 59° F.

These shallow wells, some of which began to flow when a depth of 60 to 70 feet was reached, are in a broad, deeply filled alluvial valley and evidently depend for their water supply on an alternation of pervious and impervious beds in the alluvial deposits. The source of the water for the several cold springs is no doubt the creeks which

flow from the mountains to the south, but the wells must be supplied from a deeper source.

Little Valley is situated within the Lewis artesian basin and is lower than the flowing wells near Hot Spring post-office, in Bruneau Valley, but the wells referred to above do not furnish a test of what may be termed the true artesian condition. Near the wells just described, but nearer the head of Little Valley, there is a small hot spring which rises through soft, white lake beds, and which has a temperature of 101° F. Five drill holes, put down to a depth of 40 feet in the immediate vicinity of this spring, resulted in a marked increase in the outflow. The discharge is now about one-half cubic foot per second. The wells are not cased, and there is reason to believe that larger holes, with proper casing, would lead to a greater discharge.

Guffey.—In the small valley cut by Dry Creek, about 1½ miles southwest of Guffey, Owyhee County, a well drilled to a depth of 568 feet, but not completed when examined (July 12, 1902), passes through 30 feet of loose surface gravel and then about 538 feet of soft light-covered strata belonging to the Payette formation, containing three seams of hard material, and reached a hard rock, perhaps quartzite, which checked the drill. The well is 3 inches in diameter. A surface flow was obtained from a depth of 160 feet, and an additional flow at 416 feet. The discharge is nearly 1 cubic foot of water per minute; temperature 76½° F. The well is not cased below a depth of 38 feet. Elevation at surface 2,375 feet, or about 160 feet above the adjacent portion of Snake River.

In a small gulch at Guffey and about 120 feet above Snake River, a well bored with a 1½-in. auger to a depth of 30 feet through light-colored beds, probably shale of the Payette formation, at first discharged about 1 gallon of water per minute, but has since ceased to flow.

Central.—Near Central (Barnard Ferry), in the Snake River Canyon, and from 7 to 9 miles northwest of Guffey, four artesian wells have been drilled. All of them are situated near the bottom of the valley, and within a distance of 1½ miles of Central, toward the southeast, where the elevation is approximately 2,300 feet. The records of these wells are as follows:

On the land of Alfred Cox a 3-inch well completed in June, 1902, has a depth of about 1,033 feet. It is cased from surface to a depth of 39 feet and discharges by estimate one-half gallon of water per second; temperature 100° F. Flowing water was first reached at a depth of 600 feet, and the delivery at the surface steadily increased as long as drilling was continued. The water brings sand and gravel to the surface with it. The contract price of the well was 25 cents per foot, the owner furnishing wood and water for the engine used in drilling. The casing used was also provided by the owner of the land and cost about 50 cents per foot.

About one-half mile west of the Cox well a boring approximately 1,000 deep was put down in 1901, which failed to reach water under sufficient pressure to force it to the surface. No other record in reference to this boring has been obtained.

On the farm of P. B. Smith, adjacent to the land of Mr. Cox, and about 1¼ miles southeast of Central, an artesian well drilled in 1901 has a depth of 940 feet, is 3 inches in diameter, is cased to a depth of 30 feet, and discharges about one-third of a gallon of water per second; temperature 98° F. Water which rose to the surface was first reached at a depth of 550 feet. At 700 feet a seam of black sand, etc., was penetrated and the flow of water increased. At the bottom of the well the drill dropped about 3 feet, having reached a stratum of sand and gravel, from which the main supply of water is derived. The well discharges sand and gravel. Cost about 25 cents per foot.

On the land of Mr. Barnard, about one-half mile southeast of Central, a well drilled in 1901 has a depth of about 1,035 feet, is 3 inches in diameter, cased for a short distance at the top, and discharges, by estimate, 1 gallon of water per second, with a temperature of 106° F. At Mr. Barnard's home, in Central, a well drilled in 1901 to a depth of 720 feet, delivers about three-fourths of a gallon of water per second, not measured, with a temperature of 99 or 100° F.

The four wells near Central just referred to were all drilled in the unconsolidated lacustral deposits, mostly sandy clays and soft shales of the Payette formation. A notable fact in connection with them is that no sheets of basalt were encountered. The water from each of the wells is used for irrigation.

Enterprise.—About 3½ miles down Snake River from Central or Barnard Ferry is the post-office known as Enterprise, situated near Warm Spring Ferry. Within a radius of about 1¼ miles of Enterprise and to the southeast there are 4 artesian wells.

At the home of George Newell there are 2 flowing wells, one with a depth of 340 feet, cased with 2½-inch pipe, temperature of 87° F., and the other 385 feet deep, 6 inches in diameter; temperature 90° F. The surface elevation is about 2,300 feet. The flow of water from the larger well, particularly, is strong, but on account of leakage about the pipe could not be measured. An estimate places the combined flow from the two wells at about 1 gallon per second. The water is used for irrigation. About 1½ miles southwest of Mr. Newell's home, where the elevation is 2,500 feet, a well drilled in 1901 to a depth of 165 feet, diameter 10 inches, discharges, by estimate, about 2 gallons of water per second; temperature 87° F. The water is used for irrigation. This well was begun in igneous rock, probably rhyolite, but at a depth of a few feet entered clay, and below the clay several changes in the nature of the material occurred, but an accurate record has not been preserved. Near where the well was drilled

there is a small spring of warm water. Approximately one-half mile west of Mr. Newell's ranch, on land reported to belong to Mr. Shirley, a well was drilled in 1891 to a depth of about 580 feet.

The four wells just referred to, with the exception of the 10-inch well, were drilled in the light-colored sedimentary beds of the Payette formation and, like those near Central, have surprisingly high temperatures for their depth. They are within a distance of 1½ miles of the copious hot spring at Enterprise, which has a temperature of 128° F., and, as it seems justifiable to assume, derive a part of their water at least from that or some other similar source.

Ontario.—The records of two drill holes made at Ontario, Oreg., are as follows:

A well owned by the city of Ontario, incomplete in October, 1902, has, as I am informed by Mr. A. L. Sproul, of Ontario, a depth of 1,025 feet, is 4 inches in diameter, and reached water at 195 feet, which rose to within 6 feet of the surface. The material passed through is sand and gravel to a depth of 35 feet and the remainder blue clay. The water is charged with gas, which, when properly confined, burns constantly. Cost of the well, $750.

The well just described is situated where the surface elevation is between 2,100 and 2,200 feet, or well below the artesian head of the Lewis artesian basin. The well is not cased, and the rise of the water to within 6 feet of the surface makes it probable that if proper tests of the water pressure should be made it would be found that a surface flow could be had by putting in proper casing.

The second well at Ontario, owned by A. F. Boyer, completed September, 1902, 3 inches in diameter, has a depth of 215 feet; water rose and overflowed. Gas is discharged with the water. Material passed through: Soil, 10 feet; gravel, 20 feet, and the balance shale. Cost, $100.

Vale.—A flowing well at Vale, Oreg., drilled near a hot spring to a depth of 140 feet, as already stated, discharges a strong flow of water so long as the casing is not obstructed by mineral matter deposited from it, and has a temperature of 198½° F. This well may be considered as a developed hot spring and has but little significance in reference to the artesian water supply of the basin in which it is located.

Summary.—The artesian wells near Guffey, Central, and Enterprise collectively present certain interesting facts. They are located essentially on a line extending northwest and southeast and measuring about 11½ miles. At the west end of the line is the hot spring at Enterprise. The depth of the wells and their temperatures are as follows, beginning at Guffey and approaching Enterprise:

Depth and temperature of wells at Guffey, Central, and Enterprise.

Locality.	Distance from Enterprise hot spring.	Depth.	Temperature.	Temperature gradient.
	Miles.	*Feet.*	*Degrees F.*	
Guffey	11¼	538	76½	18.42
Central	5	1,033	100	19.66
Do	4½	940	98	18.54
Do	3¾	1,035	106	17.57
Do	3½	720	100	13.40
Enterprise	1	340	87	7.83
Do	1	385	90	8.37
Do	1½	165	87	3.10
Enterprise hot spring	.....	.....	128	.....

The temperature gradient, it will be remembered, is obtained by dividing the depth of a well below the stratum of no seasonal variation in temperature, assumed as 50 feet, by the number of degrees the temperature of the water discharged exceeds the temperature of the stratum of no seasonal variation, assumed to be 50° F. The temperature gradient, then, shows the depth in feet for each increase of 1 degree in temperature.

As is indicated in the above table, the temperature gradient in the region considered increases in a conspicuous manner as the distance from the Enterprise hot spring decreases. An exceptional increase, however, is seen in the case of the last well mentioned in the table, which, as noted above, is near a small tepid spring, and no doubt for this reason shows a more rapid increase of temperature with depth than any of the others. Not considering the well just referred to, the temperature gradient increases as the Enterprise hot spring is approached, but the rate of increase can not be accurately determined from the data available, since the wells are not cased and are not supplied from the same stratum.

The facts just presented seem to indicate that the porous beds in the Payette formation in the vicinity of Enterprise are supplied in part at least from the hot spring at that place. A legitimate conclusion seems to be that the rocks beneath the Payette formation are fissured and that hot water rising through the fissure has charged the porous beds above. Whether there is a deep artesian basin beneath the Payette formation or not there are no data for judging. In general, however, hot springs rise through deep fissures and are probably in most cases not an indication of the presence of a true artesian basin. As has already been stated, the Lewis artesian basin was formed by a bending of the rocks after the Payette beds were laid

down, and this bending no doubt affected a great thickness of the earth's crust below the beds now forming the surface. For this reason it is possible that a true artesian basin exists, the porous beds of which are depressed in the vicinity of Snake River to a depth of 4,000 or 5,000 feet.

In addition to the supply of water reaching the Payette beds from below, the shape of the basin and the fact that the beds composing it outcrop in the hills and mountains bordering the Snake River Plains on the north and south make it evident that additional water may reach the central part of the basin by descending from the surface.

The most logical conclusion to be drawn from all the evidence presented in reference to the probability of obtaining water in the Lewis artesian basin seems to be that flowing water may be expected when a well is so drilled as to penetrate deeply or pass through the Payette formation at any locality within its borders where the surface elevation is less than 2,500 feet. As already stated, 2,500 feet is the minimum measure of the artesian head, as shown by existing wells, but the true artesian head may considerably exceed this amount.

The wells in Bruneau Valley, as shown by an unsatisfactory method, namely, aneroid barometer measurements, have an altitude of 2,700 feet; and the artesian head at Boise is about 2,850 feet. It is not safe at present, however, to accept any measurement of the artesian head in excess of 2,500 feet, and until more wells are drilled all attempts to obtain flowing water should be confined to localities below that horizon. It chances that nearly all the good land along Snake River and in the lower portions of Malheur Valley and much of that in Boise Valley are below 2,500 feet. Abundant localities for developing the Lewis artesian basin are thus available and should be tested before attempts are made to obtain artesian wells on the uplands.

The wells drilled in Snake River Valley at Central, Enterprise, Ontario, and other places passed through soft strata and did not show the presence of beds of basalt or other hard rock in the Payette formation. It is probable that only soft beds will be encountered in drilling to a depth of about 1,000 or 1,200 feet in the portion of Snake River Valley between Guffey and Weiser, but no positive assurance that such will be found to be the case can at present be given.

As may be judged from the facts above presented in reference to the occurrence of hot springs near the artesian well now flowing, the most favorable localities for drilling additional wells may be assumed to be near where warm or hot springs rise through the Payette formation. A qualification of this statement is suggested, however, by the fact that the hot spring at Vale is depositing mineral matter in the beds it passes through in rising toward the surface, and presumably in this way forms for itself a conduit which prevents its water from spreading laterally. This exceptional condition is also indicated by

the exceptionally high temperature of the spring referred to. In choosing a location for a well, therefore, it would be best, at least until more facts are gathered in this connection, to avoid the proximity of a hot spring that is depositing calcareous silica, tufa, gypsum, etc. The most favorable locality, so far as I can now judge, for continuing the development of the Lewis artesian basin is in the extensive flat in the Snake River Valley to the north of Sands.

EASTWARD EXTENSION.

On a preceding page it was stated that the Lewis artesian basin begins on the east near the mouth of Kinghill Creek, that limit being chosen mainly for the reason that but little land suitable for irrigation exists in the canyon of Snake River above the locality mentioned. The upraised rim of the basin extends farther east, however, but what its limits are is as yet unknown.

In my report on the geology and water resources of the Snake River Plains[a] some facts concerning artesian wells in and about the Rock Creek Hills were presented. It now seems not improbable that these wells are in reality situated in the Lewis artesian basin, and it may perhaps be shown by future investigations that the wonderful springs in Snake River Canyon, between Bliss on the west and the neighborhood of the mouth of Salmon River on the east, may be due to the escape of artesian water from the same basin. While there are no newly acquired facts to report concerning the region just referred to, lying south of Shoshone Falls, the study of the Lewis artesian basin certainly indicates that the probability of success in case wells are drilled there is greater than seemed evident when the report on the explorations was made by me in 1901.

OTIS ARTESIAN BASIN.

Otis Valley is situated on a creek of the same name in the extreme northeast portion of Harney County, Oreg., about 6 miles northeast of Drewsey. The valley has a flat bottom, measuring by estimate 5 by 6 miles in diameter, and contains a considerable amount of good land. About 1,900 acres are now under irrigation. The valley is underlain by sedimentary beds consisting largely of white volcanic dust, presumably belonging to the Payette formation. The bordering uplands are composed in part and perhaps principally of basalt, but the sedimentary beds and layers of volcanic dust which occur beneath the valley have also been bent upward in its elevated rim. The dip of the beds about the east side of the valley is west or toward its center at a low angle, and on the south side, as is revealed in the hills at Drewsey, the dip is northward. My examination was not so complete as I desired, but I think was sufficient to show that the valley is a structural basin, on the west side of which there is perhaps a break

[a] Bull. U. S. Geol. Survey No. 199, 1902.

or fault. The structure is such as to suggest the presence of an artesian basin, and in addition copious warm springs on its eastern side show that water under pressure exists below the surface. To term the region in which Otis Valley is located an artesian basin, however, will be justified only when the presence of water under sufficient pressure to force it to the surface is demonstrated, but the conditions observed seem to warrant a careful test by drilling. The pioneer well should be put down on the east side of the valley, a short distance to the west of the warm springs referred to. The area of the land below the level of the artesian head suggested by the elevation at which the warm springs come to the surface is about 10 or 15 square miles.

HARNEY ARTESIAN BASIN.

The region embraced within what is here termed the Harney artesian basin is so great that I could not in the time available examine it with the care it deserves, but I crossed it and visited various commanding summits so as to see more or less thoroughly its entire extent. The area embraced in the outer rim of the basin includes in a general way the region drained by streams which during the rainy season flow to Malheur and Harney lakes, and includes perhaps two-thirds of Harney County, Oreg. The principal streams referred to are Silvies River, which flows southward past Burns and enters Malheur Lake from the north, and Donner and Blitzen River, which rises on Stein Mountain, flows northward, and also enters Malheur Lake. The distance between the sources of these two streams is about 135 miles in a straight line. The breadth of the outer rim of the basin in an eastwest diameter is somewhat indefinite, but measures approximately 50 miles.

The outer rim of the Harney artesian basin is sharply limited on the southeast from near Andrews northeast to beyond Juniper Lake, a distance of 50 or 60 miles, by the east base of Stein Mountain. Its eastern border is in the Crow Creek Hills, and from these it passes northward and curves about the head branches of Silvies River, and then, bending southward, passes to the west of Silver Lake, Iron Mountain, and south of Harney Lake to the source of Donner and Blitzen River. The border is well defined, except in the broad region, with comparatively mild relief to the southwest of Silver and Harney lakes, where the strata are in general nearly flat. The basin is not a single saucer-shaped depression, but consists of at least two troughs or synclines, one in the region drained by Silvies River and the other on the west side of Stein Mountain and drained by Donner and Blitzen River. There are, besides, other folds and irregularities which it is not necessary to describe at this time.

The statements just given indicate that the Harney artesian basin has a structure such as is favorable for the accumulation of water in any porous beds which may be present, but before it is decisively pronounced an artesian basin other evidence should be obtained.

SPRINGS.

There are several warm and hot springs in the broad, generally flat region about Malheur and Harney lakes, but only a few of these were visited by the writer.

Burns.—On the border of Harney Valley, beginning about 3 miles southwest of Burns, a number of springs come to the surface at the base of a cliff of basaltic agglomerate. These have a temperature of from 75° to 80° F. The surface elevation is about 4,100 feet by aneroid, or the same as the general level of the broad, flat lands flooring the valley to the south of Harney and Burns. These springs are of considerable volume, and, as I have been informed, flow throughout the year without sensible variations either in volume or temperature. The water is drunk by stock, but is not used for irrigation except so far as the raising of wild hay is concerned.

Little Sage Hen Valley.—A number of springs come to the surface in the flat, alluvial lands forming the bottom of Little Sage Hen Valley, and, spreading over the land, serve to irrigate extensive natural meadows. Their temperature is in general 63° to 64° F.

Silver Lake.—On the west side of Silver Lake, and along Silver Creek, between it and Harney Lake, there are several warm and hot springs, flowing only during the rainy season, the waters of which serve to naturally irrigate the adjacent lands. The valley of Silver Creek is a broad, flat, swampy meadow, on which great quantities of wild hay are cut every year.

Harney Lake.—To the southeast of Harney Lake and about one-half mile from its shore, there is a spring of clear, tasteless water, with a temperature of from 145° to 150° F. The volume is by estimate about 6 gallons per second. An attempt to utilize the water for irrigation has been abandoned. The spring is situated near the south base of a bold hill, composed mainly of sandstone, and rises through soft, usually white, lacustral sediments resembling the Payette formation.

Malheur Lake.—In the bed of Malheur Lake, near its southern end, and exposed in summer when the lake is low, there are small springs with a temperature of 64° F. Copious hot springs occur near the eastern end of the lake and at a distance of 4 or 5 miles from the bold bordering uplands of the valley, but these were not visited by me.

Summary.—All of the springs enumerated above present the usual characteristics of warm and hot springs, and furnish evidence that water under pressure exists below the surface. They are widely separated, and in all instances except, perhaps, at the locality near Burns, rise through the soft beds which floor the Harney basin. Their high temperature in several instances indicates that the water rises from a considerable depth, but not from a depth greater than that to which the beds in the basal portion of the basin are depressed. In this connection I may state that the lacustral sediments exposed

beneath 4,500 feet of basalt on the west side of Stein Mountain dip westward at an angle of 3° or 4°, their inclination gradually decreasing, however, with distance from the outcrop, and it is reasonable to assume that they pass under Harney Valley at a depth of certainly 6,000, and probably of 10,000 or more feet. Similar evidence of the great thickness of the strata which are deformed so as to make the Harney artesian basin is furnished in the portion of its upraised rim that forms the mountains to the west of Harney and Burns. Porous beds at any such depth as that just considered, however, are, for practical purposes, beyond the reach of the drill; but as the heated water, in several instances, rises to the surface through the strata forming the upper portion of the great series of rocks involved in the deformation of the basin, and through sedimentary deposits of later date now forming the floor of Harney Valley, there are reasons for believing that the porous beds near the surface have been charged in part with water from below and furnish artesian conditions.

DRILLED WELLS.

In addition to the testimony furnished by the geological structure and by springs, certain borings made near Harney and Burns favor the hope that flowing water can be had at a moderate depth in Harney Valley.

Harney.—About 5 miles east of Harney, on land belonging to Fred Haines, sec. 2, T. 23 S., R. 32½ E., a well 3 inches in diameter, drilled in 1896 to a depth of 507 feet, struck water at a depth of between 200 and 300 feet, which rose to the surface. The well is not cased, and the water now stands 6 feet below the surface and has a temperature of 49° F. The material passed through was soft to a depth of 100 feet, and below that depth consisted of black lava, clay, etc., but no definite record is available. This well at first yielded a true artesian flow, but, as nearly as can be judged, has caved in, owing to lack of casing, and the water supply at present is from percolation through porous beds near the surface. The temperature of the water now being pumped indicates that it comes from about 50 feet below the surface and has its ultimate source in the neighboring hills. The cost of drilling the well was $1 per foot.

Burns.—A well drilled at the expense of Harney County in 1893, at a locality about 6 miles southeast of Burns, in sec. 13, T. 23 S., R. 31 E., was continued to a depth of 848 feet. The well at the top has a diameter of 6 inches, but narrows near the bottom to 4 inches. At the depth of 350 feet water was reached which rose and overflowed at the surface, but after an attempt to improve the well, made in the spring of 1902, it ceased to flow. The water in August, 1902, stood 3 feet below the surface and had a temperature of 49° F. The first 100 feet of material passed through was sand, gravel, and soft rock, and at a greater depth hard rock was penetrated, but no record as to its

nature, etc., is available. Two water-bearing strata are said to have been reached, one at 350 feet from the top, and the other at the horizon, where drilling was discontinued, namely, 840 feet. The outflow from the first water-bearing layer is said to have been small. The well is cased with iron tubing, 6 inches in diameter, to a depth, as reported, of 450 feet. The cost to Harney County was $2,400, not including the casing. The drilling was done by George W. Kellogg, of Salt Lake City, Utah. Work is said to have been abandoned on account of the loss of drilling tools in the well.

A well drilled on land belonging to Thomas McCormick, about 5 miles southeast of Burns, in sec. 12, T. 31 S., R. 24 E., completed in 1900, 6 inches in diameter, has a total depth of 68 feet. The water now rises to within 16 feet of the surface and yielded 100 gallons per hour by pumping. The material passed through was soft, and water is reported to have been reached in blue clay. The cost of drilling the well was $85 and of the casing $21.

Summary.—The evidence furnished by the drill holes in Harney Valley is meager, but so far as it goes it favors the hope that artesian water can be had throughout an extensive territory.

The well near Harney and the county well near Burns furnished flowing water and, I feel justified in affirming, would have continued to flow and to furnish a valuable water supply in each case had they been properly cased and cared for.

The well on Mr. McCormick's land is too shallow to be of significance in judging of the artesian conditions at the locality where it is situated.

Nearly all the evidence I have been able to gather in reference to the geological structure, the warm and hot springs, and the results of drilling certainly favor the conclusion that beneath the extensive plain east of Harney and Burns, on which Malheur and Harney lakes are situated, there is an artesian basin.

Conditions which may exert an adverse influence upon the value of the basin, so far as flowing wells are concerned, are the low pass on the northeast of Malheur Lake, through which the water of that lake formerly escaped, and the somewhat indefinite character of the rim of the basin to the south of Silver Lake. In addition are the "accidents" that may be present in any artesian basin, such as changes in the texture of the beds, the occurrence of breaks across the strata, and the presence of dikes.

In reference to the low pass which extends in an easterly direction from the flat country east of Malheur Lake through the hills to Camp Creek, it is evidently the lowest place in the rim of the Harney artesian basin and may perhaps determine the artesian head within the basin, but there are reasons for delaying a conclusion in this connection. The channel referred to is strongly defined and has a broad, level floor, formed by a recent basaltic lava flow. The bottom of the

previously cut river channel is thus concealed and is at least 20 to 30, and perhaps more, feet below the present surface. The highest point in the pass or old river bed (as shown, I have been informed, by surveys made with the view of drawing off the waters of Malheur Lake for irrigation purposes in Malheur Valley) is but 20 feet above the level of Malheur Lake. Evidently, then, the buried stream channel beneath the lava is lower than the broad valley lands about Malheur and Harney lakes and cuts across any porous bed that occupies the entire extent of the basin. If water-charged porous beds were cut by the channel, springs would be expected to occur in it. No springs are present, however, and it is possible that the silting over of the porous beds and the burial of the silt beneath lava has sealed them, so as to prevent the escape of water from them. While this is not such an indefinite hypothesis as it may at first seem, it does not remove all anxiety in reference to the influence of the old river channel referred to on the artesian conditions in Harney Valley. The question here raised can not be answered by the facts now known; neither can a positive opinion be expressed in reference to the position of the rocks to the southwest of Silver Lake, but my judgment is that neither of these possibly adverse conditions is of sufficient weight to discourage the drilling of test wells in Harney Valley.

From the elevations of the several localities at which warm and hot springs issue and of the surface of the two wells referred to above, the artesian head may be assumed to be at such an elevation that wells below the level of Harney or Burns would furnish a surface flow of water. The area of the basin below the horizon stated can not be accurately told at present, but embraces practically all the level land in Harney Valley about Malheur and Harney lakes and probably also the flat lands in the valley of Silver Creek and about Silver Lake. Extensive tracts of rich land in the region drained by Donner and Blitzen River are also within the area in which artesian water may reasonably be expected if drill holes properly cased are put down. A rough estimate based on the general map of Oregon, issued by the United States Land Office, indicates that the area within which artesian water may be expected is in the neighborhood of 1,000 square miles, but this includes Malheur and Harney lakes and the swamps bordering them.

To test the artesian conditions in the Harney basin, wells may be put down at any locality below the level of Burns or Harney. Perhaps the most favorable situations are near the warm and hot springs referred to, and at such places wells should be drilled on the side of the spring chosen, which is in the direction of the center of the basin or, in general, toward Malheur or Harney Lake. The depth to which wells should be drilled must be determined by experiment, as sufficient information is not in hand in reference to the sections exposed in the rim of the basin to warrant a judgment in this connection.

The successful well near Harney and Burns, however, suggests that favorable results may be expected anywhere in the basin below their surface elevation, at a depth of less than a thousand feet and possibly at a depth of only a few hundred feet. The possibilities of the basin, however, will not be exhausted when the drill has reached a depth of even 1,000 feet or, indeed, at a depth of 5 or 10 times that measure.

In the development of the basin an effort should be made to discover all of the water-bearing beds that are present within a reasonable distance below the surface, and in case several wells are drilled near each other, they should, so far as practicable, derive their water supply from different strata.

WHITEHORSE ARTESIAN BASIN.

Stein Mountain, as already stated, is the western slope of a great anticline. The central part of the upward fold referred to has been deeply eroded, and where faults occur, a subsidence has taken place. The position of the central and now deeply eroded portion of this great fold is occupied by Alvord Desert and the sharp-crested ridges running northeast from it. To the east of the Stein Mountain anticline or upward fold there is a flat-bottomed syncline or downward fold, in which Whitehorse Valley is situated. The rocks beneath this valley are bent into basin shape and the rim of the basin is high on all sides except the one adjacent to Alvord Valley. The rocks which have been bent so as to form a basin consist of reddish and brownish rhyolitic tuff in which angular fragments are conspicuous, black basalt, and light-colored and usually nearly white lacustral sediments and sheets of volcanic dust, resembling those characteristic of the Payette formation. The thickness of the beds exposed in the upraised rim of the basin—as, for example, in the mountains between Whitehorse Valley and Oregon Canyon, the next valley to the east—is several thousand feet. The bold bluffs on the west side of Oregon Canyon (which in the part here referred to is a broad valley with several ranches in its bottom) are formed of the edges of the sheets of rock, mostly basalt, which dip west and pass under Whitehorse Valley. Several springs issuing from the bluffs, well above their base, indicate that certain of the beds are water charged. These springs may reasonably be supposed to be the leakage from the basin to the west and suggest an abundant store of water beneath Whitehorse Valley.

In the southern part of Whitehorse Valley, about 6 miles south of the site of the former military post and at an elevation of fully 150 feet above the general level of the floor of the valley, there are springs with a temperature of about 100° F., which rise through soft white lake beds. In the northern part of the valley, about 10 miles north of the site of the former military post, as I have been informed, there is another warm or hot spring.

The facts stated above are such as to warrant a careful test of the artesian conditions in Whitehorse Valley. A boring should be made near the warm springs in the south end of the basin, a few rods north of the localities where their water now reaches the surface. A boring at Whitehorse ranch (the former military post) would probably yield flowing water, but the chances are nearly equally favorable all along the eastern side of the flat lands, which extend northward from the ranch for 10 or more miles. The area of good land within Whitehorse Valley, where it is reasonable to expect that flowing water can be obtained, is by a rough estimate not less than 30 square miles.

In the structure of the Whitehorse artesian basin there is one condition which may be detrimental to the occurrence of water in it under pressure, namely, the lowness of the rim of the basin on the west side in the vicinity of Sand Gap. The eroded borders of the beds emerging from beneath Whitehorse Valley there form a line of westward-facing bluffs, which define the east border of Alvord Desert. For the reason that there are no springs along the base of these bluffs, however, and for other reasons, the lowness of the rim of the basin need not be considered sufficiently important to deter the testing of the artesian conditions within it.

ARTESIAN WELLS IN ALLUVIAL DEPOSITS.

In regions like southern Idaho and eastern Oregon, which have an arid climate, and where bold mountains are bordered by wide valleys, the streams from the uplands deposit much and in many instances all of the sand, gravel, etc., which they bring down from the high-grade upper portions of their courses on the border of the valley which they enter. In this way alluvial cones or fans are built about the mouth of gorges where they open out onto a plain. These alluvial cones are not infrequently several miles in radius at the base and several hundred or perhaps 2,000 or 3,000 feet high. The apex of each cone is at the mouth of or some distance within the gorge from which the débris of which it is composed was derived, and from which a stream usually flows, at least during a part of each year. These beds of débris are thus in a position to become water charged, and their structure is such that pervious beds may be confined between impervious beds. Large alluvial cones may thus furnish conditions for the storage of water under pressure, and especially on the outer portion may yield flowing water if drill holes are put down.

Alluvial cones are sometimes greatly extended and have low surface slope, and in fact merge by insensible gradations into the flood plains of streams. This is frequently the case in arid regions, where the valleys are in many instances deeply filled with alluvium. Valleys when thus partially filled have broad, flat bottoms, with a perceptible gradient or surface slope down their courses. In such instances the surface material is usually fine, but becomes coarse at a depth of a

few feet or a few score feet below the surface, and as the beds are gently inclined the coarse beds at a depth may be charged with water under pressure. If flowing water is obtained by drilling in alluvial cones or flood-plain deposits it is normally cold, for the reason that it has not descended into the earth far enough to be influenced by the interior temperature of the earth. The water is similar to that supplied by hillside springs, and in Idaho and Oregon would have a temperature of about 50° F.

There are a few localities in the region examined by me in Idaho and Oregon where the conditions warrant the drilling of shallow wells in alluvial cones on flood plains. Some of these located in Idaho are mentioned in Bulletin 199, already referred to. In Oregon tests of the nature referred to should be made in Willow Creek Valley, to the northwest of Vale, and in neighboring flat-bottomed valleys which have a perceptible downstream slope.

The alluvial cones on the east side of Stein Mountain, at the mouths of gulches down which streams flow, should also be tested with the drill. The most promising localities for such tests are from the outer margin of a cone to midway up its slope. When the cones are steep, however, the chance of water being stored in them under pressure decreases rapidly as their summit portions are approached. The test referred to should be carried down to at least the level of the flat lands in the adjacent valley unless favorable results are sooner reached.

SIZE OF DRILL HOLES, THE CASING OF WELLS, ETC.

In the development of the artesian conditions of the Lewis artesian basin, as experience has already shown, light, portable drilling rigs will probably be all that are required, since the beds to be penetrated are soft. In the other artesian basins named, however, it seems highly desirable that only the most efficient of drilling machinery should be employed, as hard rocks will have to be penetrated in probably all wells that are more than a very few hundred feet deep. An extensive experience in drilling wells in the oil fields of the United States has shown that the best outfit for use in the artesian basins of Oregon is the square derrick walking-beam rig, provided with the best tools that can be procured. It is perhaps needless to add that only well drillers of wide experience and known integrity should be employed.

The wells to be put down should, in my opinion, be 8 inches in diameter, or drills of this size should be use to as great a depth as possible before tapering the hole to any smaller size.

In all instances the wells drilled should be well cased with iron casing. Neglect in this particular has led to failures in many instances in both Idaho and Oregon where success, as there are reasons for believing, would have been attained if proper casing had been put in. For the sake of emphasizing the statement just made, it may be truthfully said that water should not be expected to rise in a hole drilled

through rocks of various descriptions, many of them, as is usually the case, being porous, any more than it should be expected to remain in a standpipe full of holes rising above the surface of the ground. The water in an artesian well is under pressure—frequently great pressure—and tends to flow laterally wherever the rocks are porous or fissured. More than this, the walls of an uncased well are apt to cave and thus render useless all the work that has been expended on it.

In drilling a well the pressure of the water at each horizon where it is encountered should be carefully tested. One way of doing this is to lower a tube into the well, such, for example, as a three-fourths-inch iron pipe, with a leather bag filled with flaxseed encircling it near the lower end. The pipe should be lowered until its end is just above the place where water was struck. In such an experiment the flaxseed will swell and expand the bag containing it so as to shut off the escape of water about the outside of the pipe and allow it to rise within it. If the water overflows at the surface of the ground it demonstrates, of course, that an artesian flow has been secured, and if the pipe is continued upward the height to which the water rises within it will show the artesian head. Other suggestions in this connection may be found in a paper by Chamberlin, and in a report on Nez Perce County, No. 3 and No. 21, respectively, of the list at the end of this report.

Wells should be located as far apart as practicable, and when two or more water-bearing beds are present neighboring wells should have different depths, so as to draw their water supply from different sources. The distribution of wells in reference to the direction of flow of the underground water is also important. Obviously, if there is to be a series of wells, more or less in line, their alignment should be at right angles to the direction of underground flow, so as to decrease to a minimum the influence that one well exerts on its neighbor. Information in this connection is contained in the paper by Chamberlin, No. 3 of the list at the end of this report.

PRESERVATION OF WELL RECORDS.

If wells are drilled in the artesian basins described in this report a careful record of all facts concerning them should be preserved. This is a matter of great inportance to all the people interested in the development of the artesian basins, and may lead to a great saving of money in other directions. As a practical method of obtaining and preserving information referred to, I wish to suggest that it be made the official duty of the county clerk in every county where drill holes are put down for any purpose to obtain and preserve a record of the facts relating to them. To assist in doing this a schedule is here inserted which can be printed, and which, after being filled in with the data required, should be filed at the county clerk's office for future reference. The schedule referred to is as follows (for greater convenience each item should be given a separate line):

WELL RECORD.

County, ——: State, ——.
County clerk, —— ——. No. ——. Date, —— —, 190–.

Owner of well, —— ——. Driller of well, —— ——. Post-office address, —— ——. Location of well: Township ——, range ——, sec. ——. When completed, —— ——. How put down: Dug, driven, bored, drilled, ——. Size or diameter, ——. Depth: Total, —— feet; to water, —— feet; depth of water, —— feet. Did water rise when struck? ——. Does water flow over surface? ——. Height to which the water will rise in an open tube, ——. Has the flow diminished or increased? ——. Quality of water: Hard, soft, salty, alkaline, ——. Temperature of the water, ——. How is water raised? ——. Cost of well, §——. Cost of mill and pump, §——. Is the well cased? ——. Cost of casing, ——. Amount pumped or flow per hour or day, ——. Water used for ——. Elevation of surface, —— feet.

Strata passed through and remarks: —— ——.

LAWS.

As the water supply in an artesian basin may become of importance to a large number of citizens, it is obvious that laws governing its use are as necessary as the laws relating to surface waters, but, so far as I am aware, only one attempt to place legal restrictions on the utilization, or rather on the waste, of subsurface waters has been made in this country,[a] and that act fails in two particulars to meet the requirements outlined above—the proper casing of wells is not made obligatory, and the filling of abandoned wells is not provided for. Each of these regulations is highly important.

The principal restrictions and conditions which it is desirable should be established and enforced by law are as follows:

1. *Every drill hole in an artesian basin should be properly cased.*—By this is meant that an iron casing or tube lining the hole and made sufficiently tight to prevent water from rising outside of it should be put in every well which remains open. The lower end of the casing should be just above the water-bearing stratum.

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[a] The following law providing for the conservation of artesian water has been passed by the legislature of the State of Washington:

CHAPTER CXXI.

(H. B. No. 206.)

RELATING TO ARTESIAN WELLS.

AN ACT in relation to artesian wells and regulating the flow of water therefrom, and providing a penalty for the violation thereof.

Be it enacted by the legislature of the State of Washington:

SECTION 1. It shall be unlawful for any person, firm, corporation, or company having possession or control of any artesian wells within the State, whether as contractor, owner, lessee, agent, or manager, to allow or permit water to flow or escape from such well between the first day of October in any year and the first day of April next ensuing: *Provided*, That this act shall only apply to sections and communities wherein the use of water for the purpose of irrigation is necessary or customary, and providing further, that nothing herein contained shall prevent or prohibit the use of water from any such well between said first day of October and the first day of April next ensuing for household, stock, and domestic purposes only, water for said last-named purposes to be taken from such wells through a one-half inch stop and waste cock to be inserted in the piping of such well for that purpose.

SEC. 2. It shall be the duty of every person, firm, corporation, or company having possession

The reason why the owner of a well should be required by law to properly case it, as already explained in reference to the personal interest of the owner himself, is that lateral escape of the water may be prevented. The escape of water from an artesian basin in excess of the natural overflow means a decrease in pressure on the portions remaining, and consequently a lowering of the artesian head. In arid regions especially the sources of supply of an artesian basin may be small, and the question of economically using the water it contains and of maintaining the artesian head are matters of public concern.

2. *Every artesian well when not in use should be securely closed.*—The reason why a law to this effect should be enacted and enforced is that an artesian basin is not an inexhaustible reservoir, and every practicable means should be employed for its conservation and legitimate use. The closing of an artesian well when its water is not being used would in many and perhaps most instances be an advantage to its owner as well as to his neighbors, not only for the reason that his water supply would be made more permanent, but because water flowing over land in excess of the amount required for scientific irrigation is injurious.

There are exceptional cases in which it is not desirable that an artesian well should be closed at any time, as, for example, when a well is no more than a developed spring, or derives its water from what is known as an artesian slope,[a] but as such wells will probably be few in number in the artesian basins described in this report, special legislation in reference to them is perhaps not desirable.

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or control of any artesian well, as provided in section 1 of this act, to securely cap the same over on or before the first day of October in each and every year in such manner as to prevent the flow or escape of water therefrom, and to keep the same securely capped and prevent the flow or escape of water therefrom until the first day of April next ensuing: *Provided, however*, It shall and may be lawful for any such person, firm, corporation, or company to insert a one-half inch stop and waste cock in the piping of such well, and to take and use water therefrom through such stop and waste cock at any time for household, stock, or domestic purposes, but not otherwise.

SEC. 3. Any person, whether as owner, lessee, agent, or manager, having possession or control of any such well, violating the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be fined in any sum not exceeding two hundred dollars for each and every such offense, and the further sum of two hundred dollars for each ten days during which such violation shall continue.

SEC. 4. Whenever any person, firm, corporation, or company in possession or control of an artesian well shall fail to comply with the provisions of this act, any person, firm, corporation, or company lawfully in the possession of land situate adjacent to or in the vicinity or neighborhood of such well and within five miles thereof may enter upon the land upon which such well is situate, and take possession of such well from which water is allowed to flow or escape in violation of the provisions of section 1 of this act, and cap such well and shut in and secure the flow or escape of water therefrom, and the necessary expenses incurred in so doing shall constitute a lien upon said well, and a sufficient quantity of land surrounding the same for the convenient use and operation thereof, which lien may be foreclosed in a civil action in any court of competent jurisdiction, and the court in any such case shall allow the plaintiff a reasonable attorney's fee to be taxed as a part of the cost. This shall be in addition to the penalty provided for in section 3 of this act.

Passed the house March 7, 1901.

Passed the senate March 14, 1901.

Approved by the governor March 16, 1901.

[a] The nature of an artesian slope is explained in the report numbered 21 in the list at the end of this paper, page 112.

3. *Every abandoned drill hole in an artesian basin should be completely filled with impervious material.*—A desirable way in which to do this is to fill the hole slowly with moist clay and ram it down with a heavy, blunt tool, or fill the hole with Portland cement concrete. Tightly fitting rods of dry wood driven into a drill hole until it is filled would serve the same purpose.

Abandoned wells should be filled in the manner suggested in order that leakage may be prevented. Wells in which water rises some distance toward the surface but does not overflow are frequently abandoned, the casing, if any was used, having first been drawn, and in such instances a continuous escape of water occurs into cracks, porous beds, etc., about the hole.

The three rules briefly stated above should be embodied in the laws of every State in which artesian basins occur and their observance should be rigorously enforced.

For the proper development of an artesian basin it is evident that there should be but one center of responsibility. A desirable method of securing this end would be to place the entire control of the artesian wells in each State in the hands of a State engineer, whose duty it should be to determine where wells may be drilled, the depth to which they may be carried, and methods for caring for the water supply, closing abandoned drill holes, etc.

While the aim of this preliminary report is to stimulate and direct the search for artesian water in the region that has been considered, I do not wish to be understood as saying that all of the 2,000 or more square miles of rich lands contained in the four basins described can be irrigated by means of artesian water. The facts are plainly such as to warrant the careful testing of the artesian possibilities, but owing to local conditions, which are at present unknown, many difficulties will no doubt be encountered and numerous failures may occur, and even when all the wells which the water supply will justify have been put down in any one of the basins referred to there will no doubt remain extensive areas that can not be irrigated. While good results may reasonably be expected from the judicious development of the artesian basins, all the benefits that might be derived in that way will be rendered negative unless the suggestions given above in reference to the conservation of the water supply are strictly observed. I may perhaps add as a warning that the wanton destruction of the forests in this country and the now almost complete ruin of the public grazing lands throughout the arid regions leave but little hope that man's greed will be so far restricted in the case of artesian basins that ultimate failures will be avoided.

LITERATURE.

The following-named books and papers contain information in reference to artesian wells which should be of much assistance to persons desiring to develop artesian basins:

1. BARBOUR, E. H. Wells and windmills in Nebraska: Water-Supply and Irrigation Paper U. S. Geol. Survey No. 29.
2. CARLL, J. F. Report on the oil regions of Pennsylvania: Second Geological Survey of Pennsylvania, Vol. III, 1880.
   This report contains a detailed account of the methods used in drilling wells.
3. CHAMBERLIN, T. C. The requisite and qualifying conditions of artesian wells: Fifth Ann. Rept. U. S. Geol. Survey, pp. 125–173.
   This paper contains a clear and comprehensive explanation of the geologic conditions pertaining to artesian wells.
4. DARTON, N. H. Artesian-well prospects in the Atlantic Coastal Plain region: Bull. U. S. Geol. Survey No. 138.
5. —— New developments in well boring and irrigation in eastern South Dakota: Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. IV, pp. 561–616.
6. —— Preliminary report on artesian waters of a portion of the Dakotas: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. II, pp. 603–694.
7. —— Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian: Nineteenth Ann. Rept. U. S. Geol. Survey, Pt. IV, pp. 719–785.
8. —— Underground waters of southeastern Nebraska: Water-Supply and Irrigation Paper U. S. Geol. Survey No. 12.
9. GILBERT, G. K. The underground water of the Arkansas Valley in eastern Colorado: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. II, pp. 551–601.
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15. —— Wells of northern Indiana: Water-Supply and Irrigation Paper U. S. Geol. Survey No. 21.
16. —— Wells of southern Indiana: Water-Supply and Irrigation Paper U. S. Geol. Survey No. 26.
17. ORTON, EDWARD. The rock waters of Ohio: Nineteenth Ann. Rept. U. S. Geol. Survey, Pt. IV, pp. 633–717.
18. —— The Trenton limestone as a source of petroleum and inflammable gas in Ohio and Indiana: Eighth Ann. Rept. U. S. Geol. Survey, Pt. I, pp. 475–662.
19. PECKHAM, S. F. Report on the production, technology, and uses of petroleum and its products: Tenth Census of the United States, Vol. X, Washington, 1888.
   The methods of drilling wells, together with detailed plans and descriptions of machinery, derricks, tools, torpedoes, etc., are given on pages 77 to 85.

20. PHINNEY, A. J. The natural-gas field of Indiana: Eleventh Ann. Rept. U. S. Geol. Survey, Pt. I, pp. 579–742.
21. RUSSELL, I. C. Geology and water resources of Nez Perce County, Idaho: Water-Supply and Irrigation Paper U. S. Geol. Survey Nos. 53 and 54.
22. —— Geology and water resources of the Snake River Plains of Idaho: Bull. U. S. Geol. Survey No. 199.
23. —— A geological reconnaissance in central Washington: Bull. U. S. Geol. Survey No. 108.
24. SMITH, G. O. Geology and water resources of a portion of Yakima County, Wash.: Water-Supply and Irrigation Paper U. S. Geol. Survey No. 55.
25. TODD, JAMES EDWARD. Geology and water resources of a portion of southeastern South Dakota: Water-Supply and Irrigation Paper U. S. Geol. Survey No. 34.
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CHARLES D. WALCOTT, DIRECTOR

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IN

NORTHEASTERN UNITED STATES

BY

MARSHALL ORA LEIGHTON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1903

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
Washington, D. C., November 13, 1902.

SIR: I have the honor to transmit herewith a manuscript entitled "Normal and polluted waters in Northeastern United States," prepared by Marshall O. Leighton, resident hydrographer, United States Geological Survey, and to request that it be published as one of the series of Water-Supply and Irrigation Papers.

This paper is principally a review of the more readily available records, published and unpublished, of examinations made of water supplies derived from streams in the northeastern part of the United States, the principal streams examined being the Merrimac, Connecticut, Housatonic, Delaware, and Ohio rivers, and the various important branches of the latter in the States of Pennsylvania and Ohio. It is, in effect, an account of the important work done in river examination up to the present date, a few unfinished inquiries now in progress being omitted.

The introduction treats of the characteristics of normal and polluted waters in general and seeks to explain, in language intelligible to those not versed in chemistry, the meaning and importance of the various determinations made in an ordinary water analysis. In dealing with the various rivers which have been subjected to examination, wherever the courts have been invoked to pass upon the legality of any existing state of pollution, or to adjust damages occasioned thereby, the cases are cited and pertinent excerpts are given from the decisions.

This paper forms one of a series of reports on examinations made as to the character of the natural waters of the United States and the pecuniary damage to municipal water supply occasioned by city and industrial wastes. It is expected that examinations of like nature will be undertaken by the Survey in cooperation with the various universities and State laboratories in the country, the character of the work differing according to the conditions and demands in each case.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey,
Washington, D. C.

NORMAL AND POLLUTED WATERS IN NORTHEASTERN UNITED STATES.

By M. O. LEIGHTON.

INTRODUCTION.

In order to properly determine the water resources of a country, and to define the limitations of use which apply to various rivers, it becomes necessary to know the character of the water in each case. Water is a source of wealth by reason of the uses to which it may be put, and these are dependent to a large extent upon the nature of the water. It follows, then, that for each branch of water utilization there is established a standard to which water must reasonably conform, in order that it may properly fulfill the requirements of the particular case.

By reason of their physical features and their artificial development, different rivers may possess characteristics which make them very different in their form or kind of utility. Sewage pollution may destroy every resource of one river, yet may not sensibly affect the value of another. One stream may be highly useful as a source of power; another may be best utilized primarily as a commercial highway; still another may serve as a source of water supply. There are waters which are more valuable as a disposal area for manufacturing refuse than they would be if maintained unpolluted as fishing grounds or ice fields. Therefore a thorough hydrographic investigation should serve to indicate the peculiar uses to which a stream is best applicable, and by it we should be able to determine the normal resource in each case and the damage done by unwise or unlawful procedure. Of especial importance is the fact that the utilization of a river in one State may be so damaging to its purity that the people of another State through which the same river flows may be totally deprived of its use, and, under present conditions, with little if any opportunity for redress.

Let us glance briefly at the characteristics that are demanded of waters required for different uses.

ESSENTIAL QUALITIES OF WATER FOR VARIOUS USES.

Commercial highways.—The character of a water has nothing to do with its use as a means of transportation. For this purpose it is

only necessary that it shall be sufficient in amount to float vessels and that the course in which it runs shall be deep and broad and uninterrupted by impassable obstructions.

Power.—For utilization as a source of power a stream should have sufficient grade to allow the conservation of large quantities of water behind dams, so that it may be forcibly delivered upon water wheels, and, by means of the power developed by this impact, may operate mechanism applied to human purposes. If the gradient is abrupt—that is, if it is largely concentrated in one or several places, so that the water falls over precipices or runs in rapids—the power available will be greater and the expense of development will be less than if the fall of the stream is gentler or the stretches between rapids are longer. The constituents of a water used for the development of power are not of great importance except in such cases as its impounding by dams may be the means of holding back or depositing accumulated impurities which become a source of discomfort and thereby depreciate the value of real estate.

Manufacturing.—It is essential that a water used in manufacturing processes shall not contain anything which, from a chemical or sanitary standpoint, shall be injurious to the products of manufacture. The manufacturing uses to which water is put are very numerous, and when it is to become one of the constituent parts of the product it is necessary, in most cases, that it shall be pure and not liable to damage the product by reason of any substances which it may carry in solution or suspension. If, on the other hand, it is intended that the water shall be employed merely in the process of manufacture, as in washing products or in dissolving ingredients, it is readily apparent that foreign substances in the water may defeat this purpose.

Use in boilers.—Normal or pure water has a certain action upon metals, iron being one of those easily affected. If, therefore, a pure water is used in a boiler there must necessarily be some action which has its part in shortening the term of usefulness of the boiler. When a water is used which contains ingredients that hasten this action upon iron or which deposits sediments within the boiler, the usefulness of the boiler is shortened unduly, and the value of the water as a boiler water is lessened by an equivalent amount. An idea of the damage done by calcareous matter in water, which is deposited as an incrustation within the boiler, can be formed by considering the experience of the engineers on the Nebraska Division of the Union Pacific Railroad, where the water used held in solution a large quantity of sulphate of lime and magnesia. When such water is boiled the sulphate is deposited on the inside of the container. The expense of cleaning and repairing boilers by reason of this deposit amounted in two years to $2,860, equal to 8 cents per mile of distance run. In addition to this the total mileage of each engine was probably reduced one-half

Fisheries.—It requires only a slight study of the subject of fresh-water fisheries to appreciate how acute is the effect of water pollution upon the living organism. Many waters in the United States that were once good fishing grounds have, within recent years, become destitute of fish because of the dumping of wastes from factories or public sewers into lakes or rivers.

Nuclei of parks.—The development of park systems in this country is a striking revelation of a growing civilization. That there should be recognized, in this highly commercial atmosphere, the need of establishing pleasant places of rest, where the careworn citizen may escape for a short season from his business encumbrances, is a cause for gratification. No one has properly estimated the value of these shelters to the workingman, the isolated housewife, or the dust-stifled child. It is fast becoming the conviction of popular representatives that the people have a right to retain unto themselves certain convenient portions of the country in its natural state. Of such there could be many within easy reach of every city, but too often their establishment is made impossible by the foulness of the water flowing past available sites or standing close by in natural reservoirs. A body of pure water is the proper nucleus of such a place, for bathing, boating, fishing, and pleasant atmosphere are all necessary accompaniments of the perfect park. But in a place where bathing becomes suicide, boating resembles a voyage with Charon, and even breathing taxes the strong stomach, there is little prospect that a park will be established.

Ice supply.—The requirements of a water to be used as a source of ice supply closely resemble those hereinafter described with reference to water supply. The difference lies in the fact that a large proportion of foreign matter in water is excluded upon the formation of ice. Just how much is yet uncertain, but the most recent investigations show that the microorganisms which produce disease do not live long in ice.

Irrigation.—Water used for purposes of irrigation must contain none of the various mineral impurities, such as those found in manufacturing wastes, which are known to have a deleterious effect upon vegetation. This danger to irrigation is so remote as to be unworthy of a passing remark. Irrigation districts are not, and probably never will be, manufacturing ones.

Drinking water.—The standards set for a drinking water are more precise than those prescribed in any other branch of water utilization. Water is necessary to the continuance or even the existence of life, powerfully affecting human beings for better or for worse according to its character, and as the immediate preservation of human life is the principal object of society, this phase of the water question is more important than all those previously discussed.

It is not necessary that a water for public supply shall be chemically pure; indeed, such a water would be in many ways undesirable. Generally speaking, that which flows off or out of the land in its

natural state is usually well suited to the needs of man. If, however, in flowing out of a drainage area it becomes contaminated with the ejecta of man or of domestic animals; if into the courses in which it flows there is emptied the refuse from mills and factories; if upon the land drained by the stream there has been spread any animal refuse whatsoever, then the run-off water will be changed in character, and even though it may subsequently be treated, naturally or artificially, in such a manner that it is not prejudicial to health, it will bear to its final destination the marks of its former bad associations.

The value of a water is commonly reckoned according to its availability for public consumption. To be acceptable to the public it must have little or no turbidity and must contain little or no sediment or organic waste, color, taste, or odor. It will, therefore, be useful to follow the course of a quantity of water from its source in the ocean around its cycle of changes until it again reaches the ocean, in order to show how great are the obstacles that prevent it from meeting these several requirements.

IMPURITIES IN NATURAL WATERS.

RAIN WATER.

Water is raised by evaporation from oceans, lakes, ponds, and from the surface of the earth, and carried aloft, there to float in the form of clouds until the air sustaining it is saturated, when it is condensed and precipitated upon the earth. In falling through the air rain water naturally washes out any impurities held there in suspension. These impurities consist of dust composed of organic and mineral matter, such as pulverized earth, soot, pollen, and dried and finely divided particles of plants and insects, as well as ammonia, carbon dioxide, sulphuric acid and other gases, all of which are dissolved or held in suspension by water. Consequently when the rain strikes the earth it is not, as is commonly supposed, pure water. The amount of impurities it may contain depends on local conditions. If the air washed is that lying over a large manufacturing city it is manifest that the water on reaching the earth will be less pure than that falling upon a primeval region. Nevertheless, even in the latter case, the air always contains a certain amount of foreign matter. It is also manifest that rain water falling during the later part of a storm will be purer than that which first fell, for after a time the air will be cleared of its impurities.

On striking the earth, assuming that it falls on a mountain or on sloping land, there are several courses that water may take. Some of it is immediately absorbed by vegetation or directly evaporated from the earth's surface as it was from the ocean. The larger part, however, takes two other courses: (1) It runs directly off the surface in rivulets, converging into rills, streams, brooks, and rivers; (2) it sinks into the earth and, after filtering to a greater or less depth, reappears as springs or is intercepted by wells. Let us first follow that which runs directly along the surface of the earth.

SURFACE WATERS.

Some of the impurities which the water gathered in the air are lost as soon as it comes in contact with the earth, but in its course along the surface many more are gathered up—particles of sand or silt; pieces of dried or decayed leaves, wood, and grass; microscopic insects, and myriads of bits of other material of an almost imponderable nature which in the aggregate amount to a surprisingly large quantity. These particles ultimately are dissolved, or if sufficient time is not afforded to dissolve them they are deposited on the bottom of the stream in places where the current of the stream is checked. We have, therefore, the following classification of impurities in water:

Impurities in water.

- 1. Suspended matter
  - Inorganic or mineral: Sand, clay, and various pulverized minerals.
  - Organic
    - Animal: Living microscopic animals, dead fish and pieces thereof, feathers from birds, etc.; decayed animal refuse; manufacturing wastes, such as wool scourings, blood from slaughterhouses, etc.; excrement from sewers, etc.
    - Vegetable: Dried leaves, grass, and flowers, decayed wood, peaty matter; algæ and other plant life, including bacteria; wastes from cotton, silk, and linen mills, and from distilleries, etc.
- 2. Dissolved matter
  - Gaseous
    - Carbon dioxide.
    - Hydrogen disulphide.
  - Solid
    - Inorganic metals in general.
    - Organic
      - Animal (see above).
      - Vegetable (see above).

Organic matter.—Water as it passes over the earth, therefore, becomes more and more impure, the extent of its pollution depending on the character of the matter which it gathers up and carries along or which is poured into it by artificial means. Matter which is merely held in suspension would not seriously affect the character of water but for the phenomenon of solution, by reason of which the state of suspension is not permanent, for sooner or later a large part of the suspended matter is dissolved. It is a familiar sight to see inorganic matter dissolve in water, and the process seems simple; but the explanation of the solution of organic matter presents difficulties. How is it brought about? In order to explain this it will be necessary to discuss briefly the composition of organic matter.

Organic matter—that is, matter which is the product of life processes—consists chiefly of the four elements, carbon, oxygen, hydrogen, and nitrogen. These elements stand closely in union as long as life endures. Immediately upon the occurrence of death, however, there comes a breaking down. The chemical combination in the original living matter may be expressed thus:

Oxygen—Carbon
| × |
Hydrogen—Nitrogen.

When there is no longer a bond of union between the four elements there comes dissociation and a reuniting of elements having attraction one for the other. In this case one of the first steps in the breaking down of the above combination may be expressed as follows:

Oxygen—Carbon
Nitrogen—Hydrogen.

The oxygen in this and in the other processes here described is derived to only a limited extent from the decaying organic matter itself, but is drawn in large part from the atmosphere and from the store of oxygen suspended in the water. The oxygen and carbon combination, known as carbon dioxide or popularly as "carbonic acid," combines with other elements or goes into solution as such, and its connection with the old combination is permanently severed. The nitrogen and hydrogen combine and form ammonia. This completes the first step in the process. We have the organic matter, once in suspension, then in solution, now broken up into two very familiar compounds, both inorganic.

The process is not yet finished. The combination, nitrogen-hydrogen, is not a strong one. It is easily disturbed in several ways, and one of these is the introduction of more oxygen, which is nearly always present in water and always in air and in innumerable chemical combinations. Both of the above elements are more strongly attracted by oxygen than they are by each other, and therefore there is a further breaking up. The next step may be represented as follows:

Nitrogen—Oxygen—Hydrogen
Hydrogen—Oxygen.

Now the hydrogen-oxygen combination is water, a very stable compound, and therefore that portion of the hydrogen and oxygen which is combined as indicated in the diagram is permanently disposed of. No further change takes place in it. Not so with the nitrogen-oxygen-hydrogen. As it is first combined, one part of nitrogen and one part of hydrogen, hold together two parts of oxygen, so that the combination is more accurately expressed:

Nitrogen { Oxygen—Hydrogen.
Oxygen.

This combination would remain stable if there were not more oxygen present and available. But as the element nitrogen can hold in combination three parts of oxygen, there can be no permanent chemical compound formed until this possibility is accomplished; so another change takes place, and the nitrogen finally holds three parts of oxygen, thus:

Nitrogen { Oxygen—Hydrogen.
Oxygen.
Oxygen.

The first compound is one of the substances that are necessary to the formation of a nitrite; the second forms the foundation for a nitrate, the essential distinction between these consisting of a difference in the amount of oxygen present. A nitrite represents a very unstable, transitory combination, which takes place in the oxidation of organic matter, and which in any case is not permanent. A nitrate, however, represents the final condition of mineralized organic matter. It is the stage where the decay of that which was formerly living matter stops, when every chemical demand is satisfied. A nitrate is a permanent, stable compound which is not readily broken up nor acted on by other elements or compounds.

It must be remembered that the changes above described, as will hereafter be noted more fully, take place in the presence and by the action of living organisms, and while the processes roughly outlined are not so simple as has been indicated, the foregoing explanation will nevertheless, it is hoped, give a general idea of their character. As a concluding remark, it is sufficient to note that under the circumstances the condition of nitrogen in a water faithfully represents the condition of the organic matter in that water.

Bacteria.—Having traced the changes that take place in the organic matter of a surface water, let us now consider the means by which such changes are effected. In the list of organic materials above enumerated it will be remembered that bacteria found a place among those matters "suspended." It is by their agency that the changes above described take place. They are not the bacteria which are known to produce disease, but they belong to the great and useful species of the order. They are found primarily in the air and in the ground, and their presence is indispensable to the reduction of waste organic matters to the inorganic elements from which they are made up. Along with the pollen, the soot, and the fine particles of animal and vegetable matters in the air, these bacteria are collected by the rain falling to the earth. When they are brought to the earth in rainfall they immediately begin the work of changing the organic matter, and they are at once reenforced by the myriads which are always present in the ground. The greater the amount of organic matter carried along by the water, the greater the number of bacteria that gather to reduce it, so that the number of bacteria found in a water is an accurate measure of the amount of organic matter it contains. Their presence in large amount does not necessarily signify that the organic matter is dangerous, but the very fact that there is sufficient food to sustain great numbers of bacteria is sufficient indication that putrefactive processes are going on in the water, the true significance of which must be ascertained before the water should be accepted for domestic use. Animal matter is more highly putrefactive than vegetable matter, and, except under extraordinary conditions, a high number of bacteria is indicative of animal pollution.

Algæ.—There is another great branch of the plant kingdom which exerts a powerful influence upon the purification of surface waters: This is the group Algæ. These are the minute green plants which, in stagnant pools, grow in such large numbers as to occasionally form what is popularly known as a "scum" over the surface. These plants subsist upon the products of decomposition of organic matter. As soon as the bacteria succeed in breaking down the complex organic combination as above described, these algæ grow abundantly and feed upon the products of decomposition. As the change from ammonia to nitrites and nitrates is made, they continue to consume the débris, so that the tendency is to clear the water of such matter. If such a water were placed in a glass and no further pollution were allowed to enter, it would be found that after a short period the ammonia, nitrites, and nitrates would be greatly reduced. It is also true that the algæ themselves live to maturity and die, contributing more organic matter to the water. But, unless the conditions are such that an overabundant growth is induced, and the living algæ can not consume the débris of their dead ancestors, the supply of organic matter from this source is not such as to materially affect the condition of the water from the standpoint of total organic nitrogen.

These algæ ofttimes contribute odors, tastes, and color to the water as a result of their life processes and their decay, so that in all cases their presence is not wholly beneficial from a sanitary standpoint. Such odors and tastes are characteristic and can be readily detected. The action of algæ described above is not fully exerted unless the water is quiet, or practically so, for a short time, although there is no doubt that some action takes place in running streams.

Algæ also feed upon carbon dioxide set free by the action of bacteria upon organic matter. The recent studies along this line are very instructive, and seem to clear up an important point which has, for a long time, not been fully understood. The purifying process which has been supposed to exist in the extensive aeration of water, like that tumbling down over a cataract, has been found to have very little effect upon the state of organic matter in the water. Dr. Thomas M. Drown, in a memorable experiment, found that after air had been blown through water for an extended period very little change had resulted in the condition of the organic matter. The work served to emphasize the fact that bacteria are all important in the oxidation of organic matter, and that the process is distinctly different from the oxidation of an inert mineral substance. It was therefore believed that the splashing of a brook down the side of a mountain had no purifying effect. Recent work has shown, however, that this process is beneficial, not on account of the absorption of oxygen in the water, but by reason of the expulsion of the carbon dioxide from it, so that the algæ, deprived of a large part of their food, would not be likely to grow to an extent that would make their presence objectionable.

Disease germs.—There is one other requirement demanded of a drinking water which, although inseparably linked with much that has gone before, must nevertheless be treated by itself. This requirement is, that a water used for domestic purposes shall not contain the specific germs or bacteria of ground-borne diseases, such as typhoid fever and cholera. It has been stated that in all waters in which the decomposition of organic matter is going on there are bacteria, which are requisite to the furtherance of this decomposition. It has also been shown that, although these bacteria are not productive of any specific disease, their presence in large numbers in a given water is a satisfactory indication that there must be a correspondingly large amount of decaying matter in the water to provide them sustenance. Experience has shown that a water which during a long series of examinations shows an average of more than 150 to 200 bacteria per cubic centimeter merits careful investigation. The presence of disease-producing bacteria is a matter which requires special consideration.

The bacterium commonly occurring in the United States is the bacillus of typhoid fever. This disease has its seat in the human intestine, and the infective material is naturally ejected during the course of the disease, and is carried along through sewers to the place of disposal. If this is a river the water therein becomes infected with germs of this disease, and the infection is communicated to persons drinking the water farther down the course. It is well known that the natural habitat of these bacteria is not in water, and therefore their life is not continued for a long period. Just how long this period is, however, is very uncertain; it surely has no connection with the period required to mineralize organic matter. Therefore the absence of the latter in its unoxidized state is no guaranty that dangerous bacteria are not absent. Their term of life probably varies widely, depending upon the local conditions, temporary or permanent.

UNDERGROUND WATERS.

Heretofore we have considered only that part of the water of precipitation which, upon striking the earth, flows directly off the surface into streams. That part which sinks into the ground is of equal importance, for it constitutes the reserve supply from which streams are replenished after the influx due to a rainfall has spent itself. All ground waters must at some time issue from the ground in the form of springs, wells, etc., and, flowing along in courses, become surface waters.

Basis of interpretation.—The fitness of ground water for public supply must be determined in ways very different from those used in determining the potability of surface waters. When rain water sinks into the earth it meets conditions which are highly favorable to the oxidation of the organic matter it contains. The water sinks slowly down through the particles of sand, the faces of which are covered

with the bacteria that bring about oxidation. Under such conditions an enormous extent of bacterial surface is exposed to the water, and the change of the organic matter from albuminoid ammonia to nitrates is exceedingly rapid and complete. Consequently, when such water emerges from the ground it is to be expected that the amount of ammonia and nitrates will be exceedingly small or absolutely wanting. When a spring water is found which possesses these ingredients, it is practically certain either that the water was originally a surface water which, upon entering the earth, has quickly passed below the layer of available oxygen in the ground, so that the normal process of decay has been retarded, or, having been once freed from its organic matter, has become contaminated with the contents of some sewer, cesspool, drain, or other source of waste matter. It is not an easy task to discriminate between these two possibilities unless there is at the disposal of the investigator a table or chart showing the amount of normal chlorine of the water of the locality within which the spring is located. With such information at hand, it is necessary only to compare the amount of chlorine found with the normal amount for the locality to ascertain whether the contamination is local or arises from natural phenomena. It has therefore become the practice of sanitarians to demand that a ground water shall contain little or no unoxidized organic matter. The amount of nitrates found in such a water is nearly always large, sometimes rising, in perfectly safe waters, to a very high proportion. Such results indicate an extensive previous pollution, which has been thoroughly cleared up. The element of danger in waters of this kind is the possibility that there might at some time be such a change in conditions controlling this oxidation that the process would fail of completeness.

Storage of ground waters.—When ground waters are stored in reservoirs in the presence of sunlight there is a quick and profuse growth of algæ in the basin, due to the abundant presence of nitrates which serve for food. Under such circumstances it is necessary to cover the reservoirs when it is desired to preserve ground waters in their original state.

SANITARY ANALYSES.

It will now be instructive to consider sanitary analyses and their significance. A sanitary analysis of water is not the determination of its mineral constituents and the quantity of each, but consists of the observation of a few physical characteristics, such as color, turbidity, odor, etc., and a determination of the different forms of nitrogen it contains, the amount of which, as has been remarked, is a faithful representative of the character of the organic matter in the water. It should be distinctly borne in mind that the ingredients which are determined in such an analysis are not harmful of themselves, and, as such, have no significance whatever. They are simply

guideboards which point out the way to a knowledge of the true condition of the water.

In Table 1 is given an analysis of a normal water in the State of Massachusetts.

TABLE 1.—*Analysis of a normal water from Massachusetts.*

[Parts per million.]

Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.		
Decided	6.0	1.252	0.000	0.000	0.000	1.1	51.5

Turbidity.—The term "turbidity," in the first column, defines itself, and in the analysis above set forth the degree of turbidity is expressed by the word "decided." The terms here used to express various degrees of turbidity, from lowest to highest, are as follows: "Very slight," "slight," "distinct," and "decided." This nomenclature is now used in only a few laboratories. In more recent analytical procedure turbidity is expressed according to a standard scale, the details of which are described in Circular No. 8 of the Division of Hydrography of the United States Geological Survey.

There are several highly important reasons for knowing turbidity, which make necessary the fine adjustment of an apparatus for its determination. Turbidity is a physical condition of water which must be measured by comparison with standards which are arbitrarily adopted. A clear water is most acceptable as a beverage. The most slovenly of mankind have an inherent dislike for a turbid draft, and even horses refuse to drink a water of doubtful appearance. Turbidity is the result of various causes, and a trained observer can infer a surprising number of facts concerning the history of a water and the condition of the area from which it comes by a superficial survey of the visible foreign matter held in suspension. A highly turbid water is unsuitable for many domestic and manufacturing purposes, and therefore the accurate determination of the degree of turbidity at the beginning of an investigation in some cases obviates the necessity of further work.

Odor.—The determination of the odor of waters is important, as from it we can sometimes determine the origin of the water or the pollution which it contains. Odors are often imparted to water by the green plants which grow in it, sometimes to a disagreeable extent. For a description of the method of describing odor, reference should be made to Circular 9 of the Division of Hydrography.

Color.—Returning to the analysis above set forth, the color denoted as 6.0 means that, compared with an arbitrary standard, prepared

and adopted as such, this sample bears the relation of 6 to 1,000,000; that is, a standard brown color having been determined upon, the sample under investigation is compared with known dilutions of the standard, and the dilution having the tint nearest to the sample is the one which designates the color of the water.

Nitrogen.—The next division of the analysis is entitled "nitrogen," and is subdivided into "albuminoid ammonia," "free ammonia," "nitrites," and "nitrates."

Albuminoid ammonia.—Albuminoid ammonia represents the nitrogen in the original combination referred to above; that is, before decomposition has set in. From the results of the determination of the amount of albuminoid ammonia in a sample of water we can infer with a fair degree of accuracy the amount of organic matter it contains. This does not, however, give any clue as to the character of the organic matter, whether animal or vegetable. We may find in a polluted water a smaller amount of this ingredient than may exist in a normal water perfectly acceptable for drinking purposes. In the analysis reported above is set down a comparatively large amount of albuminoid ammonia, 1.252 parts per million; this water, however, is unpolluted by dangerous wastes. On the other hand, in several waters the nature of which is known to be very dangerous, there were found only 0.284, 0.196, 0.198, 0.262, and 0.263 parts per million. The determination reveals, then, only the quantity of organic matter present, and in order to decide whether it is of a dangerous nature or not we must look further. If it is found that the organic material is principally vegetable matter, which is far less susceptible to decay than animal matter, the water which contains it may be fit for household purposes if the taste, color, odor, etc., are acceptable. This, however, can not be determined by analysis, but must be the result of inspection of the water course.

Free ammonia.—Free ammonia is the product of the first process of decay of organic matter. Its presence, as such, in a water is not more harmful than that of albuminoid ammonia. It denotes that decomposition is incomplete; that it has been arrested or retarded. It is not necessary, nor, indeed, natural, that any considerable inhibition of the process of decay should take place, and when such retardation occurs, as is shown by a high proportion of free ammonia, there must be some cause for it. We have said that a controlling factor in this process of oxidation is the presence of oxygen. Now, if a water contain a large amount of organic matter in a putrescible state, its breaking down into carbon dioxide and ammonia may go on so rapidly that it consumes all or nearly all of the available oxygen. This is certainly the case with sewage, in which there is a large amount of organic matter undergoing rapid decomposition. In the following reports of analyses this is well illustrated. The first is a repetition of what is found on page 23, while the second is that of a polluted water.

TABLE 2.—*Analyses of a normal and a polluted water from Massachusetts.*

[Parts per million.]

Character of water.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.		
Normal	Decided	6.0	1.252	0.000	0.000	0.000	1.1	51.5
Polluted ...	Slight	1.5	.263	.664	.025	.800	24.1	127.0

It will be seen upon examination of the above that in the polluted water the turbidity is less than in the normal water, the color considerably less, the total residue smaller in amount, and the albuminoid ammonia only 22 per cent of that in the normal water. When, however, we observe the comparative amounts of free ammonia, we find that in the unpolluted water there is none, while in the other there are 0.664 parts per million. This satisfactorily bears out the statements made in the preceding paragraph. It is evident that although the albuminoid ammonia in the polluted water has been so oxidized that the amount remaining can not be regarded as high, the free ammonia has not decreased in proportion. The cause of this must therefore be that the organic matter in the polluted water is so readily decomposed that it has consumed or was consuming all the available oxygen at the time the analysis was made. The fact that in the normal water there is reported no free ammonia indicates one of two conditions: (1) Either that algæ have consumed, as food, all the free ammonia as fast as it has been made, or (2) that the organic matter is not readily oxidized. We shall consider further on just which is the most likely deduction. High free ammonia may therefore be an indication of sewage pollution; at any rate it implies a rapid decomposition of organic matter.

Nitrites.—The presence of nitrites in a water is another indication of the incomplete oxidation of organic matter. It is only one step further in the process of oxidation, and as such, it must bear much the same significance as the presence of free ammonia. A nitrite is an even less stable condition of nitrogen than free ammonia; in fact, it represents nothing more than a short period of transition between free ammonia and the nitrates. Even in sewage-polluted waters it does not occur in so large a proportion as do the other forms of nitrogen. Rapid indeed must be the initial stage of oxidation of organic matter in order to allow the accumulation of nitrites. According to the analyses reported in Table 2 there are no nitrites contained in the normal water, but there are 0.025 parts per million in the polluted sample. The latter amount may be regarded as extremely high, and, taken with the high free ammonia, is almost certainly due to sewage pollution.

Nitrates.—The nitrates found in a water represent the complete mineralization of organic matter. When such matter, from whatever source derived, has reached this state it is entirely harmless. This is by no means equivalent to saying that a water with a high amount of nitrates and an insignificant quantity of the other forms of nitrogen is safe for drinking. There is no necessary connection between the amount of nitrates and the good or bad qualities of the water for public use. The question of the presence of the specific germs of disease is all-important and will be hereinafter considered. The presence of nitrates in a water, therefore, indicates nothing more than "previous sewage contamination." Of itself it is quite insignificant, but, taken into consideration with the determinations heretofore discussed, forms the final link in the chain which secures for us a knowledge of the history of a water under examination.

On referring again to the two analyses in Table 2 it will be noted that the amount of nitrates in the polluted water is large, indicating previous pollution. Yet it does not in any sense indicate that that pollution was dangerous. The report of analysis of the normal water shows that there are no nitrates. This is both uncommon and interesting. The amount of albuminoid ammonia in this sample is large, and under ordinary circumstances we might reasonably expect that there would appear at least a characteristic amount of the end product—nitrates. But as none appears we must conclude from the analysis that the organic matter in the water is of a kind that resists decomposition, and that as fast as the process is accomplished the algæ consume the ammonia, so that none appears in the various stages of oxidation.

Chlorine.—Little or no mention has been made of this substance in the previous pages in order that the discussion of the changes which take place in organic matter might not be complicated by other considerations. Few if any determinations in the whole range of water analysis are as important as that of chlorine. It bears absolute testimony concerning the history of the water, and its interpretation is dependent upon none of the other determinations. It may be under certain circumstances the crucial test by which a water may be accepted or rejected for potable use.

It is well known that chloride—that is, a chemical combination of chlorine with another element of a certain class, such as silver, magnesium, potassium, or sodium—are found in the earth in quantities varying according to the chemical nature of the geological formations. The most common of these is sodium chloride, familiarly known as common salt. These substances dissolve in water, some readily, others slowly, so that water that has passed through or over the ground is nearly always found to contain chlorides, generally common salt. Salt is found in the air, especially near the seacoast, and is one of the component parts of organic matter. The water

which flows over the surface of the land bears onward to the ocean an appreciable amount of salt in solution, a fact which is attested in a familiar manner by the saltness of the ocean and some of our great lakes which have no outlet. The wind blowing over the sea, driving it into spray, raises fine particles of salt, which are carried through the air over the land. These particles, being brought down by the rain, influence the amount of salt which is found in normal waters.

The work of the Massachusetts State Board of Health in the determination of the amount of common salt in normal waters has become classical. In a long series of analyses of normal waters selected in every part of the State it was found that there are distinct regions in which the amount of salt does not vary, except within very narrow limits, and that areas of equal normal chlorine may be defined upon a map of the State. It was found that the boundary lines of such districts follow roughly the coast line, and as the coast is receded from the amount of salt in normal waters grows less. This work has been taken up in Connecticut, Vermont, New Jersey, Ohio, and various other States. (See fig. 1.) How is such a map to be put to practical use? Before considering this question it will be necessary to take up the matter of significance of common salt in surface waters.

Common salt is composed of sodium and chlorine in equal proportions. Therefore, if it is desired to determine the amount of salt in a given water, it is only necessary to isolate one of these elements and the amount found will represent the whole. It is, for known chemical reasons, better to determine the chlorine, and therefore in an analysis of water like that in Table 1 the column "chlorine" represents the amount of chlorides, usually common salt.

We have said that salt is one of the component parts of both animal and vegetable matter. When a surface water is collected into a stream it contains chlorine that has been derived from vegetation as well as from the air and earth. Now, the amount of chlorine to be gathered from the vegetation of a district is as constant as that derived from the air or ground. When, however, animal matter is poured into the water there is an immediate rise in the amount of chlorine, which, obviously, can not be accounted for by any change in the natural conditions of the drainage area. It is clearly a contribution from sources other than those normally existing. The waste products of man, such as urine and fæces, and of the household, such as garbage and wash water, contain large amounts of salt, and when such waste is turned into a river its presence is easily detected. Now, the use of a normal chlorine map becomes apparent; whenever the water from any district is analyzed it is only necessary to compare the content of chlorine found with the normal content for that district, as shown on the map, and if the analysis shows a higher amount there is only one deduction to be made—that is, the water is or has been polluted with sewage.

When chlorine is once introduced into a water it remains there throughout the journey to the sea, accumulating according to the normal content of the country or the pollution introduced. The organic matter may be completely oxidized, generations of algæ may mature and die, color, hardness, turbidity, odor, and all else may change, but chlorine remains fast. Public sewers may be introduced into a river and change it to a stream of reeking filth; miles may afterwards be traversed; sedimentation, oxidation, and the most subtle filtration may take place, and the water may again be suitable for drinking, yet the actual amount of chlorine carried along by the stream does not, under usual circumstances, decrease appreciably. It may appear in smaller proportion at one point than at another, but

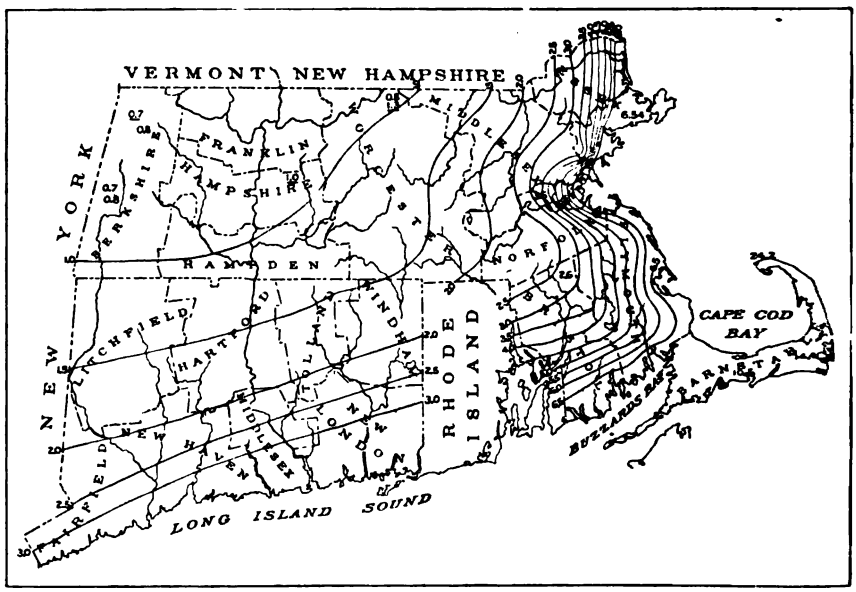

FIG. 1.—Normal chlorine map of Massachusetts and Connecticut.

not by reason of any reduction of the actual amount of chlorine. To illustrate, the water of the Blackstone River just below the Worcester precipitation works contained in the year 1900 an average of 15.7 parts of chlorine per million; after flowing a few miles to Uxbridge it contained 13.8 parts, and finally at Millville, a short distance above the State line, it contained only 9.3 parts. The river in its progress from Worcester to Millville receives a comparatively large amount of pure water from its tributaries, also a large amount of pollution from different establishments along its course, but the amount of sewage added is in no way proportional to the amount of pure water contributed. Therefore the proportion of chlorine to water must grow less all along the course from Worcester to Millville. It is obvious that the

proportion of chlorine is never reduced to an amount equal to the normal, and therefore must bear evidence of former abuse. The abnormal chlorine in a water may be likened to the scar left from some ugly wound; although the parts may be united and the surrounding tissues be healthy, yet the mark of former injury can never be effaced.

Total residue.—Under "Total residue" are included all matters, organic or mineral, which serve to pollute the water. In the above analysis it means that if 1,000,000 parts of water were evaporated there would remain in the container 51.5 parts of residue, which would represent practically the weight of the total impurity.

Analyses of normal and polluted waters.—The following analyses of normal and polluted waters, taken from the special report upon the "Examination of water supplies," made by the Massachusetts State Board of Health in 1890, are very useful in illustrating the principles above set forth. The first set of analyses represents normal waters and the second polluted waters.

TABLE 3.—*Analyses of normal and polluted waters.*

[Parts per million.]

NORMAL WATER.

No.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.		
1	None	0	0.022	0.000	0.000	0.060	0.8	50.0
2	Decided	1	.702	.000	.006	.030	1.0	25.0
3	do	6	1.252	.000	.000	.000	1.1	51.5
4	Slight	4	.333	.130	.001	.250	1.6	36.5
5	do	3	.136	.000	.000	.050	6.3	32.5
6	do	0	.152	.000	.000	.060	21.0	59.5

POLLUTED WATER.

7	Distinct	1	0.284	0.124	0.009	0.150	1.9	107.5
8	Very slight	5.5	.196	.000	.004	.550	5.4	51.5
9	Distinct	1.0	.198	.016	.004	.200	5.8	50.0
10	Slight	1.5	.262	.000	.010	.170	20.9	102.5
11	do	1.5	.263	.664	.025	.800	24.1	127.0

Careful examination of the above table shows that chemical analyses alone may furnish very little information concerning the healthfulness of a water unless certain matters determined are in exceedingly high

proportion. Analysis 11, in Table 3, for instance, is such that a person could, with a fair degree of safety, condemn the water. The free ammonia, nitrites, and chlorine are high, giving evidence which is unmistakable. Sewage is poured into the body of water from which this sample is taken.

Supposing, however, this series of analyses was not divided into "normal" and "polluted," how would we be able to place 8 in its proper position under "polluted waters?" The results of the determinations in this analysis appear lower than some of those in the normal list. On comparing it with 4, for instance, it will be seen that in the polluted water the turbidity is less, the color not much more, the total amount of organic matter not greatly different. The free and albuminoid ammonia are much less in the polluted water; the nitrites are considerably more, but not so great as in normal water 2. The nitrates are higher, but this, as has been explained, means little so far as the healthfulness of the water is concerned. The marked difference in the two seems to be in the amount of chlorine, but if we glance at the normal chlorine map (fig. 1) it will be seen that if 8 were collected in the region of Boston and 4 were collected farther west, these amounts of chlorine would both be normal. If we do not know where they were collected or whether the nitrogen compounds are the result of decomposition of harmless vegetable matter or dangerous animal waste, the bare water analyses are nearly worthless; but taken in connection with a knowledge of the locality, population, and sewerage conditions within the drainage area, the analyses are preeminently useful in determining the conditions of the water.

Hardness.—Some of the damages done by the use of hard water have already been referred to under the title "Use in boilers" (p. 14). In a public supply a hard water is troublesome and expensive by reason of the fact that when it is used for household washing it requires a larger amount of soap to produce the desired result. The fatty acids in the soap must first neutralize the calcareous matter in the water before it can be used for washing. A uniform scale for the determination of hardness is at present the subject of considerable thought among water analysts. The present methods, however, are efficient to a certain degree of accuracy and enable us to distinguish a soft water from a hard one.

There are two grades or kinds of hardness which will, wherever possible, be distinguished in the following pages. The first is due to the presence of alkaline carbonates, such as calcium, sodium, and magnesium carbonates. When water containing these compounds is boiled their effect quickly passes off; consequently it is designated as "temporary hardness," or, as it will be termed in this review, "alkalinity." The second grade of hardness is due to the presence of alkaline sulphates, chlorides, and nitrates. They do not disappear upon

boiling, and therefore maintain a "permanent hardness" or "normal hardness."

In the succeeding pages, in the case of New England, where the total hardness—that is, both temporary and permanent together—has been determined, the amounts indicating the degree of hardness are the result of a reduction of the amounts of all alkaline earth salts to terms of an equivalent amount of carbonate of lime. In other words, in Table 7 the statement of the hardness as 11 means that the water contains an amount of alkaline salts which make it as hard as would have been produced by 11 parts of carbonate of lime per million. In the statement of the hardness in the case of waters in the Ohio Basin, on the other hand, where the hardness is divided into "temporary" and "permanent," the temporary hardness indicates the amount of alkaline carbonates reduced to an equivalent of calcium carbonate; and in the case of permanent hardness, the amounts include the alkaline sulphates, chlorides, and nitrates reduced to an equivalent of calcium carbonate.

Summary.—In the preceding pages an attempt has been made to briefly and plainly state the characteristics demanded of a water required for public and household uses. Many details have been purposely omitted, but it is believed that enough has been said to enable the reader to comprehend the changes that take place in the dangerous or undesirable ingredients common to water supplies, a knowledge of which is necessary to a proper understanding of the contents of the following pages.

POLLUTION OF NATURAL WATERS.

The pollution of natural waters, though it may be sometimes unavoidable, is usually highly damaging to the resources of the country in which it takes place. The matter is a troublesome one in populous countries and has occupied the attention of chemists, engineers, land promoters, and others, as well as of courts of law, having been a fruitful source of litigation. The basis of action in all cases of this character is founded on the principles of common law in respect of the ownership of real property. The title of a land owner presumptively extends upward to the clouds and downward to the earth's center, embracing everything upon the surface and beneath it. This includes the mineral wealth in the ground and arising out of it, such as coal, iron, copper, oil, water, and even gas. The water flowing from a spring situated upon a certain piece of property belongs to the owner of the land as truly as do the blades of grass that grow upon it. A water right, whether it be vested in a spring, well, or river, is appurtenant to the land and passes with it by conveyance. The ownership so secured carries with it the assurance that all water passing out of or over the property shall be normal, and that any pollution

other than that caused by the natural drainage of occupied land lying above is actionable in law.

The situation is well summed up in a few paragraphs from the American and English Encyclopedia of Law, volume 28, under the heading "Water courses:"

Riparian rights are the correlative rights of adjoining proprietors upon the banks of water courses with respect to the water thereof. * * * The property in the water is indivisible, and all proprietors are entitled to an equality of rights therein.

In consequence of the common right of riparian proprietors to the benefits of water flowing through their land the general rule is that no proprietor has the right to use the water to the prejudice of another. This principle, however, does not restrain the use of the waters, so that there can be no diminution or impediment whatever, but the true measure and standard of the use which a riparian owner may make of his right is the reasonableness thereof. Each is entitled to a reasonable use for domestic, agricultural, and manufacturing purposes, * * * reasonable with respect to the rights of others.

A right to a reasonable use includes the right to release, let down, and discharge waters in order beneficially to employ them; and the exercise of the right entails no liability for injuries necessarily caused thereby to others in regard to the rise of the stream; yet if the discharge withdraws from another the use of the waters to which he is entitled, or if it needlessly deprives another of his beneficial use, or injures or destroys another's property, a case for damages is presented.

The right to the reasonable use of the water of a stream not navigable that flows through ones land includes the right to confine and obstruct its flow with dams in order to utilize the water power, or, for other beneficial purposes, to detain the water for such a length of time as it may be reasonably necessary for such use, notwithstanding the detention injuriously interferes with another's exercise of his right to the reasonable use of the stream in its natural state.

The right of every owner of land through which a stream of water flows to have the same flow in its natural state extends to the quality as well as the quantity of water, and therefore one who pollutes or contaminates water may be liable to those injured thereby, and a court of equity will interfere by injunction to restrain such use as will cause an irreparable damage or endanger the complainant's rights by adverse possession if continued.

A frequent ground of action arises from the operation of mills and factories, the refuse from which poisons, corrupts, and renders unwholesome the waters of a stream, or in some other way impairs it usefulness. The deposit of dyestuffs, whereby a stream is polluted or discolored; the discharge of poisonous or corrosive substances into a stream, whereby the machinery of lower riparian owners has been injured; emptying offensive matters from tanyards, and deposits of sawdust waste or refuse of mills to the injury of lower proprietors, have been held to be actionable and proper grounds for injunction.

A riparian proprietor who pollutes a stream by an unreasonable discharge of sewage, to the injury and inconvenience of lower riparian owners, is liable for damages therefor. If a muncipal corporation causes sewage to pollute a water course, to the use of which a lower landowner through whose premises it passes is entitled, it is guilty of a nuisance, for which damages may be recovered.

It appears, then, that there is no legal justification for the pollution of water, yet so universal is the practice that it has come to receive moral justification at the hands of society and meets no general con-

demnation except in cases where it goes beyond the bounds of human endurance. A few States in the Union have recognized the damage arising from water pollution and have made intelligent investigations for the purpose of correcting the evil. The results of some of these investigations will be presented in the following pages, together with the results of examinations made by several towns and cities as a consequence of local necessities. The data are arranged according to drainage areas, and in the case of interstate rivers, where the work has occurred in several States, the results obtained for a particular stream will be combined.

MERRIMAC RIVER BASIN.

GENERAL FEATURES AND METHODS OF UTILIZATION.

Course and drainage area.—The Merrimac drainage basin is 4,553 square miles in extent. (See fig. 2.) It is situated in New Hampshire and Massachusetts, occupying in the latter State 1,136 square miles. The Merrimac River proper is formed by the junction of the Winnepesaukee and Pemigewasset rivers at Franklin, N. H., from which place to its mouth, at Newburyport, Mass., it is about 110 miles long. From Franklin it takes a south-southeasterly course until it passes for a short distance into Massachusetts, when it abruptly turns northeastward and enters the Atlantic Ocean.

There is a wide variation in the physical characters of the Merrimac Basin. A large part of it is highly cultivated and fertile, but at the headwaters of the different tributaries the country is exceedingly rough and rugged. A small part of the area is low and swampy. Forests worthy of the name are almost entirely wanting in large parts of the basin, their absence causing a certain inconstancy in the flow of the river, but this has been in a measure corrected by a thorough system of storage, natural and artificial.

Throughout the basin the underlying rock is largely granite, which furnishes a valuable source of supply for building materials.

Storage.—Within the drainage area of the Merrimac are many lakes, ponds, and artificial reservoirs which afford excellent storage, and, as has been stated, compensate in a measure for the effects of extensive deforestation. The most important of these are Lake Winnepesaukee and Long Bay, covering 71.75 square miles; Squam, New Found, Belmont, and Massabesic lakes, Smiths and Suncook ponds, and a long chain of reservoirs in Massachusetts, which conserve a water supply for the "Metropolitan district."

Transportation.—The river is not important as a means of transportation. Small coastwise vessels may ascend as far as Haverhill only, and the amount of traffic is not large.

Power.—As a source of water power the Merrimac throughout its

whole extent is justly famous. In the main river there is a total fall of 269 feet in 110 miles, an average of 2.45 feet per mile. This fall, however, is concentrated at six principal points, giving most advan-

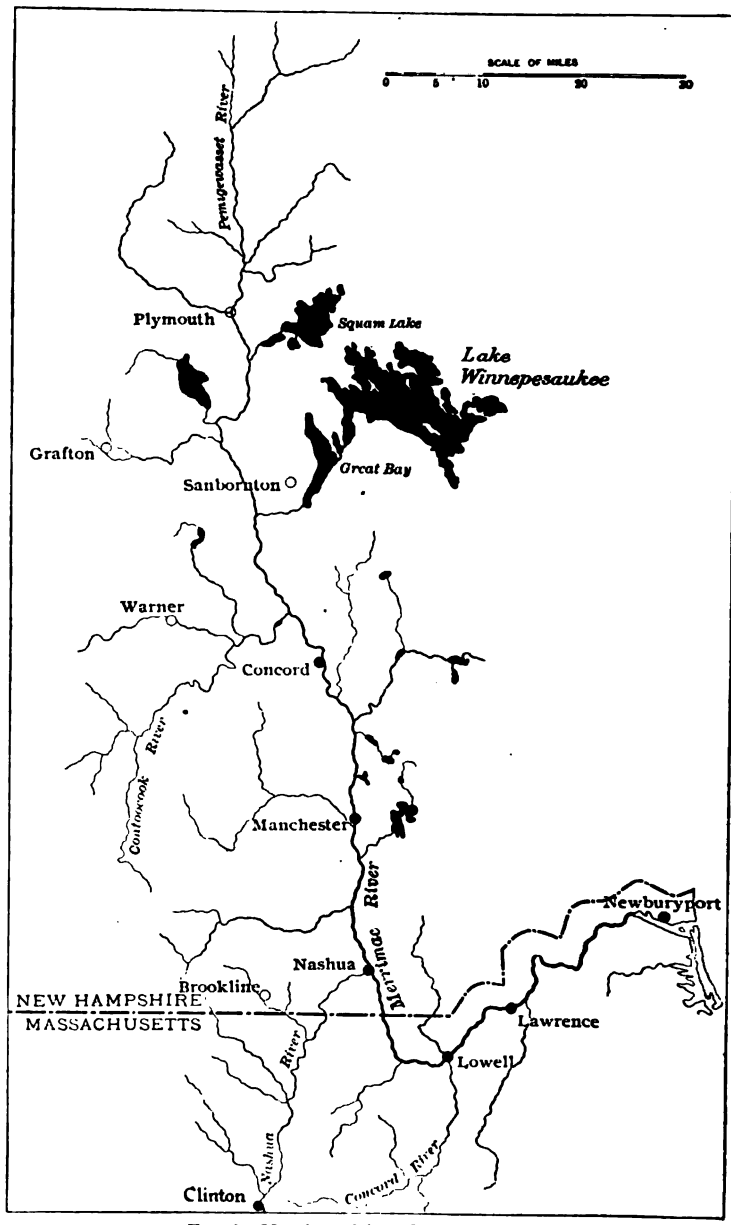

FIG. 2.—Merrimac River drainage basin.

tageous power facilities. Up to the present time there have been utilized over 40,000 horsepower at Lowell, Lawrence, and Manchester.

On the tributaries, too, there are a large number of power sites, which have been utilized extensively. In Table 4 is given the total utilized horsepower on each important tributary. Some of these, especially in the drainage area of the Concord and Nashua rivers, have been abandoned to make way for the metropolitan water-supply system.

TABLE 4.—*Utilized horsepower of tributaries of Merrimac River.*

Branch.	Total utilized horsepower.	Drainage area (square miles).
Powwow River	1,850	50
Shawsheen River	645	72
Spickett River	701	79
Beaver Brook	687	92
Concord River	4,962	380
Stony Brook	904	35
Nashua River	11,762	516
Souhegan River	2,451	224
Cohas Brook	170	44
Piscataquog River	1,250	214
Suncook River	2,881	264
Soucook River	72	90
Contoocook River	6,360	766
Winnepesaukee River	6,503	480
Pemigewasset River	4,114	1,013
Total	45,312	

Ice.—With the exception of Lake Winnepesaukee there are no very large ice fields within the Merrimac drainage area. Taken collectively, however, the ice industry is very large, each pond or lake which has remained sufficiently pure being the source of supply for the country immediately surrounding. There are no reliable records of the size of the ice crop within this basin. The industry is largely localized, each field having a different ownership, and the returns made by the different owners are certainly not correct, for the endeavor to escape taxation has induced the several companies to make returns which are usually far below the actual amount of ice cut. The common measurement of ice in the fields is 1,000 tons to the acre, the ice being about 12 inches thick. Within the Merrimac Basin it is possible to cut two or three crops. According to the Tenth Census report on water power there are about 100 square miles of pondage in this basin, equal to 64,000 acres. Assuming that 25 per cent of this area is available for ice cutting and allowing for only one crop during the season, which is certainly a low average, there would be available

160,000 tons on the lakes alone. Allowing for a large crop on the rivers, it appears that 1,000,000 tons a season is a conservative estimate, and the total amount cut is probably far more than this. At all events, the value of this system as a source of ice supply is very great.

FLOW MEASUREMENTS.

During a series of years the flow of the Merrimac has been carefully measured at Lawrence, and the discharge is given in the following table:

TABLE 5.—*Estimated annual discharge of Merrimac River at Lawrence, Mass.*

[Drainage area, 4,553 square miles.]

Year.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1890	31,560	590	9,373	6,785,786	27.93	2.06
1891	39,000	280	8,370	6,033,916	24.84	1.48
1892	24,800	225	5,869	4,264,911	17.58	1.29
1893	44,800	286	4,850	4,726,807	19.47	1.43
1894	27,900	104	5,035	3,645,052	15.03	1.11
1895	65,300	71	5,799	4,196,973	17.25	1.27
1896	82,150	183	7,187	5,203,029	21.40	1.58
1897	41,499	176	8,002	5,800,105	23.90	1.76
1898	36,000	372	8,413	5,092,341	25.05	1.85
1899	38,200	50	6,464	4,672,824	1.42	19.20

On the Sudbury River, tributary to the Concord, measurements of flow have been regularly made since the year 1875, and are set forth in the following table:

TABLE 6.—*Mean flow of Sudbury River in cubic feet per second, 1875–1900.*

[Drainage area, 75.2 square miles.]

Year.	Second-feet	Year.	Second-feet.	Year.	Second-feet.
1875	111	1885	105	1895	134
1876	118	1886	126	1896	119
1877	141	1887	134	1897	114
1878	169	1888	197	1898	153
1879	104	1889	176	1899	113
1880	67	1890	149	1900	126
1881	114	1891	150		
1882	100	1892	90	Mean	124
1883	62	1893	120		
1884	131	1894	89		

CHARACTER OF NORMAL WATER IN THE MERRIMAC BASIN.

The waters of the Merrimac have been studied more carefully, probably, than those of any other river in the world. The Massachusetts State Board of Health, famous for its pioneer work in modern river survey, has determined very closely the character of the water in that part of the drainage area that lies within the State. No work of importance has been done by the State of New Hampshire, but the waters of the Winnepesaukee have been carefully analyzed by the Commonwealth of Massachusetts. The natural conditions in the drainage area are, however, sufficiently uniform to warrant the assumption that the normal characteristics of the headwaters in Massachusetts are representative for the whole area.

Tables 7 and 8, the first consisting of analyses of practically normal surface waters and the second consisting of analyses of normal ground waters, will fairly serve as an index of the character of unpolluted water in the Merrimac Basin. The last column in these tables shows the number of analyses on which the averages stated were based.

TABLE 7.—*Analyses of normal surface waters in Merrimac Basin.*

[Parts per million.]

Place of collection.	Turbidity.	Color.[a]	Nitrogen as—				Chlorine.	Total residue.	Hardness.	Number of analyses made.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.				
Sudbury reservoir		2.2	0.175	0.030	0.001	0.054	2.2	36.2	11	52
Framingham reservoir.	Slight to decided	1.9	.170	.022	.001	.037	2.3	36.3	12	12
Ashland reservoir	do	6.8	.223	.012	.001	.047	2.4	37.2	11	(b)
Nagog Pond, Acton	None to slight	.5	.170	.005	.000	.011	2.4	20.9	2	11
Scott reservoir, Fitchburg.	Slight to decided	1.6	.227	.008	.001	.020	1.4	26.1	2	4
Haynes reservoir, Leominster.	do	1.6	.304	.016	.000	.020	1.0	18.7	1	4
Morse reservoir, Leominster.	Very slight to slight.	2.3	.198	.007	.000	.030	1.2	21.0	2	4
Sandy Pond, Concord.		.3	.129	.001	.001	.041	2.5	26.6	.....	.....
Crystal Lake, Haverhill.		1.3	.166	.009	.....	.030	3.0	32.2	.....	.....
Lake Winnepesaukee.		1.0	.093	.002	.000	.008	c1.2	20.9	.....	24
Penacook Lake, New Hampshire.[d]		1.0	.138	.020	.000	.000	1.4	32.0	11	1

[a] Nessler scale.
[b] Over 80, extending over 13 years.
[c] Excess of chlorine, 0.2.
[d] Furnished by H. E. Barnard, New Hampshire State Laboratory of Hygiene.

TABLE 8.—*Analyses of normal ground waters in Merrimac Basin.*

[Parts per million.]

Place of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	Number of analyses made.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.				
El-Hazar, Lowell	2	0.012	0.004	0.000	0.025	1.0	24.0	5	2
Ballardvale, Andover	3	.012	.003	.000	.035	2.4	23.5	4	2
Framingham	1	.025	.000	.000	.065	2.2	38.0	17	2
Pepperell	1	.006	.003	.000	.065	1.5	53.0	24.5	2
Concord	0	.025	.006	.000	.200	2.6	26.5	4	3
Methuen	0	.012	.003	.000	.150	2.0	85.0	21	2
Chelmsford	2	.022	.006	.000	.510	2.8	27.0	6	1
Dracut	2	.077	.008	.000	.040	2.7	33.5	6.5	2
Well in Sandbarton	0	.000	.000	.000	.300	1.76	55.0	2.0	1

POLLUTION IN THE MERRIMAC BASIN.

The country drained by the Merrimac River system contains a population of about 632,560, according to the national census of 1900. Of this number, 414,040 dwell in Massachusetts. The population per square mile within the whole area is therefore 151; that in New Hampshire is 71.4; that in Massachusetts is 364.4. A large proportion of this population is concentrated within cities and large towns, so that the above figures do not, even approximately, represent the actual conditions in the drainage area.

Pollution exists in the basin to an extent that has made the waters a fruitful source of study. On the main river, between Newburyport, Mass., and Concord, N. H., there is a large civic population supplied with sewerage systems, from which large volumes of crude sewage are daily poured. Some of the tributaries also receive a damaging amount of pollution. The latter will first receive attention, and their effects will be gathered together and summed up in connection with the pollution in the Merrimac proper.

SHAWSHEEN RIVER.

Rising in the historic town of Lexington, Mass., the Shawsheen runs in a northerly direction and enters the Merrimac at Lawrence. It is a somewhat unimportant stream from the standpoint of natural resource; the flow is unsteady and the power values poor. As a source of water supply it would furnish in the driest year about 20,000,000 gallons of bad water daily from the 34.1 square miles on the upper end of the drainage basin.

The population of the portion of the area above mentioned is about 125 per square mile, and appears to be growing rapidly. Few precau-

tions have been taken to keep the waste from this number of people out of the river, and the country is highly fertile and swampy to a large degree, so that the water of the river contains an abundance of organic matter and has a high color.

Analyses of the water of the river have been made by the State Board of Health, as follows:

TABLE 9.—*Analyses of water from Shawsheen River.*

[Parts per million.]

Place of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	Number of analyses made.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.				
Bedford	Slight	15	0.311	0.000	0.002	0.035	5.9	76.7	12	2
Wilmington	None to distinct.	9.6	.272	.018	.001	.085	3.5	56.3	.....	24
Andover	Slight to decided	5.1	.385	.074	.001	.047	4.2	55.7	13	3
North Andover	Slight	8.5	.306	.106	.005	.250	3.6	53.5	13	1

The special report of the State Board of Health of Massachusetts, made in 1895, upon the metropolitan water supply has the following:

It was the general opinion from 1874 to 1887 that the water of the Shawsheen River was of satisfactory quality for the purposes of a public water supply; but the investigations of the State board of health since the latter year have shown that this is not the case. The population upon the watershed (123 per square mile) is not very large, but the headwaters of the stream are in the town of Lexington, within 10 miles of the statehouse, where there is likely to be a large growth in the future, and the territory in and beyond Lexington is used to an increasing extent for market gardening. The watershed also contains many swamps, from which the water acquires a high color and takes up much nitrogenous organic matter.[a]

CONCORD RIVER.

Sudbury and Assabet rivers join at Concord, Mass., to form the Concord, which from this point flows in a northerly direction to join the Merrimac at Lowell. (See fig. 3.) The country drained by the system varies in character, a part being extremely flat meadow land, through which the river winds sluggishly, while the remainder is of the hilly, rolling character common to Massachusetts. The Assabet Basin and the upper part of the Sudbury are of the latter character, but the Lower Sudbury and the Concord, from the town of Concord to Billerica, are very flat. Two miles from its junction with the Merrimac there is a fall of 40 feet in the Concord, corresponding to the fall in the Merrimac at Lowell.

[a] Report Massachusetts State Board of Health upon a Metropolitan Water Supply, p. 114.

Pollution in the Concord system has been accurately determined. The Upper Sudbury is set apart as a drainage area for a part of the supply of the Massachusetts metropolitan district, and for years

FIG. 3.—Concord River drainage basin.

accurate analyses have been made. The Assabet has been examined with reference to its use as a future source of supply, and the Concord has received attention all along its course.

SUDBURY RIVER.

Drainage area.—In the Sudbury area the city of Boston had six reservoirs built or started, utilizing the water from Farm Pond and Lake Cochituate, when the control was put into the hands of the Metropolitan Water Board. The drainage area here included is as follows:

	Sq. miles.
Reservoirs 1 to 6	74.656
Farm Pond	.543
Lake Cochituate	18.87
Total	94.069

Within this area are Marlboro, Southboro, Westboro, Hopkinton, Ashland, and the largest populated portions of Natick, Framingham,

Sherborn, and Wayland, all representing a population of about 45,300, or 482 per square mile.

Conditions in the area.—That waters can be conserved in so populous an area and delivered in good condition to the citizens of Boston without any purification save that occasioned by storage may be considered remarkable. It is commonly found that a river running out of a valley having so many persons per square mile as live in the basin of the Sudbury is so polluted that its use in the raw state is dangerous. The examination of the condition of the Shawsheen showed what may be expected even in a country with a population of 125 per square mile. It will therefore be profitable to consider the conditions

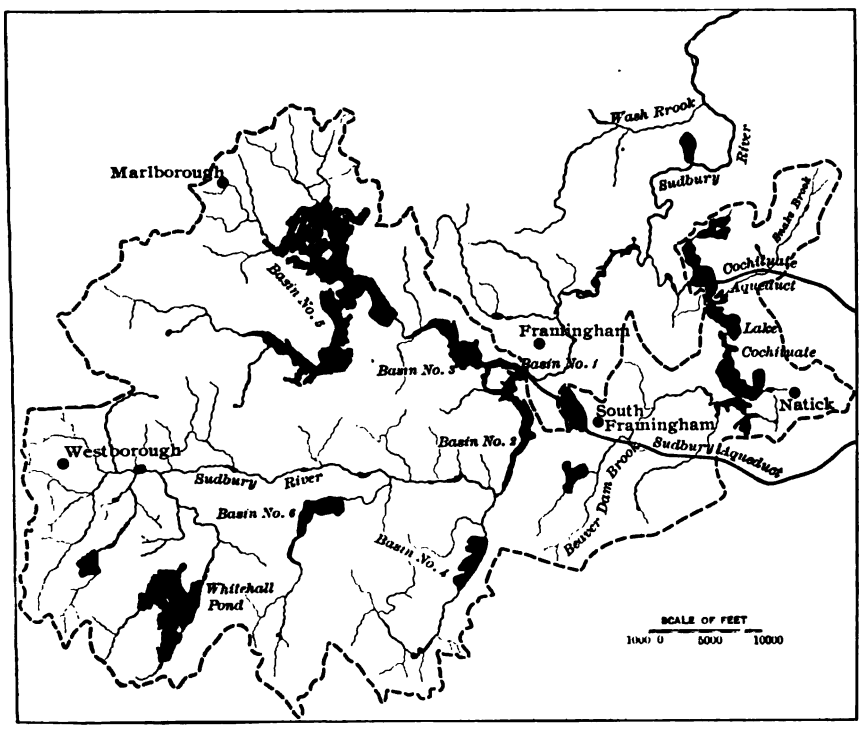

FIG. 4.—Sudbury River drainage basin.

within the Sudbury area and show how it is possible to maintain the run-off water in a normal state.

Examination of the accompanying map of the area (see fig. 4) will show that Westboro is situated on the western divide of the Sudbury, and just beyond the divide is the sewage-disposal work for the town. On the northern boundary is Marlboro, a city of importance, and to the east, over the divide, is another disposal works. In the stream known as Walker Brook, running through Marlboro to the great Sudbury reservoir, has been placed a filter, and all of the water from the

city of Marlboro, which, as shown by analysis, is extensively polluted, is purified before being mingled with the pure water in the reservoir. Within the Cochituate Basin are South Framingham and Natick, both with sewerage systems and sewage-disposal works the latter situated outside of the drainage area. In addition to this, a filtration system has been established at the Reformatory Prison for Women, while the water of Pegan Brook, running from Natick into Lake Cochituate, is filtered like that of Walker Brook in Marlboro. The differences between the waters of this area and those of others having an equal population are due entirely to these precautions.

Out of the Sudbury and Cochituate basins there were daily drawn in the year 1902 about 41 million gallons of water. If it were not for the filtration of polluted water described in the foregoing paragraph, the water from this area would be quite unfit for domestic use, and this large investment would diminish in value or would fail completely. It would be necessary to filter the entire output, which would cost at least $5 per 1,000,000 gallons, or, at the present rate of consumption, $74,800 annually. Under the present conditions the expense of sewage purification in the Sudbury and Cochituate basins amounts to a small fraction of this sum annually. Thus by an expenditure of a small amount of money for the construction of disposal works and a comparatively insignificant amount for maintenance the value of the Sudbury resource is preserved. This is a typical case, illustrating what may be done in the way of preserving in its normal state the water of a populous district. It stands forth in contrast to the many cases hereinafter taken up, in which all thought of preservation of values undamaged is thrown to the winds.

Character of water.—The character of the water in the Upper Sudbury Basin is well set forth in the first three analyses in Table 7, page 37. It will be seen that from all evidences the precautions taken are successful, for the waters are practically normal. The Cochituate water is also nearly normal and is similar in many respects to that of the Sudbury, possessing, however, a much lighter color. The color of the Sudbury water has been improved during recent years by the drainage of swamp lands in the watershed.

Passing out of the hilly region, the Sudbury winds along the plain through the towns of Sudbury, Wayland, and Lincoln, carrying along the incidental pollution from these places as well as that from Framingham Center and the effluent from the Natick, Marlboro, and Framingham filter beds. This pollution has its effect upon the river, as is shown by the marked change in the character of the water. The following analyses of waters, taken along the Sudbury, Assabet, and Concord at different points, are reproduced from the report of the Massachusetts State Board of Health for 1900.

TABLE 10.—*Analyses of water from Sudbury River between Saxonville and Wayland (Farm Bridge).*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	No.	Place of collection.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.					
Aug. 15, 1900	Very slight.	3.4	0.216	0.040	0.002	0.000	3.6	40.0	16	1	Dam above Saxonville Mills.
Aug. 29, 1900	do	2.2	.244	.012	.000	.080	3.6	40.0	16	2	Do.
Do	Decided	8.0	1.500	.390	.000	.020	9.0	118.0	22	3	3,000 feet below Saxonville dam.
Feb. 27, 1901	do		2.720	5.040	.013	.200	11.1	162.5	27	4	4,000 feet below Saxonville dam.
Aug. 15, 1900	do	6.1	1.000	.110	.007	.010	7.3	90.5	20	5	1 mile below Saxonville dam.
Do	do	6.1	.850	.140	.004	.010	6.9	108.0	22	6	2.7 miles below dam.
Aug. 29, 1900	do	3.3	.600	.300	.004	.090	8.7	92.5	26	7	Do.
Feb. 27, 1901	do	6.0	.940	.940	.070	1.020	16.8	153.0	29	8	Do.
Aug. 29, 1900	Slight	3.0	.336	.136	.000	.020	8.0	69.5	26	9	4.1 miles below dam.
Aug. 15, 1900	do	3.0	.292	.136	.004	.010	6.3	74.5	25	10	6 miles below dam.
Aug. 29, 1900	do	2.9	.376	.092	.003	.010	8.3	80.0	26	11	Do.
Feb. 27, 1901	do	2.7	.206	.172	.018	.420	6.8	71.5	25	12	Do.

TABLE 11.—*Analyses of water from Sudbury River between Wayland and Concord.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	No.	Place of collection.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.					
Aug. 11, 1900	Slight	2.9	0.246	0.072	0.005	0.080	6.6	61.5	22	13	Canal bridge.
Aug. 29, 1900	Very slight.	3.6	.258	.046	.002	.020	6.3	62.5	23	14	Do.
Feb. 27, 1901	do	2.9	.214	.244	.010	.410	6.5	64.5	22	15	Do.
Average		3.1	.239	.121	.006	.153	6.5	62.8	22	....	
Aug. 15, 1900	Very slight.	3.0	.260	.022	.004	.000	5.6	56.0	23	16	Lee's bridge.
Aug. 29, 1900	do	2.3	.244	.060	.000	.020	6.8	58.0	20	17	Do.
Average		2.6	.252	.026	.002	.010	6.2	57.0	21	....	
Aug. 15, 1900	Very slight.	3.0	.226	.026	.001	.000	6.0	54.0	20	18	Heath's bridge.
Aug. 29, 1900	do	1.9	.222	.024	.000	.030	5.8	58.5	18	19	Do.
Feb. 27, 1901	Slight	3.6	.250	.142	.006	.380	6.2	71.5	20	20	Do.
Average		2.8	.233	.064	.002	.137	6.0	61.3	19	....	
Aug. 15, 1900	Very slight.	3.0	.262	.044	.002	.000	5.8	55.0	22	21	Near mouth Concord.
Aug. 29, 1900	do	2.2	.222	.034	.000	.010	5.5	59.0	21	22	Do.
Feb. 23, 1901	Slight	3.2	.274	.122	.005	.290	6.0	64.5	21	23	Do.
Feb. 27, 1901	do	3.7	.284	.144	.005	.380	5.9	65.0	21	24	Do.
Average		3.0	.260	.086	.003	.170	5.8	60.9	21	....	

Findings.—The dates of collection of the samples reported in Tables 10 and 11 are well selected to show the character of the water in Sudbury River in midsummer and midwinter seasons. The analyses given show clearly the effects of pollution on the river along the entire course, from the borders of the restricted area to the mouth of the Assabet, in Concord. Samples 1 and 2, taken from the dam above Saxonville mills, show the effects of contamination from Framingham Center in the content of chlorine. The normal chlorine map shows that the proper amount for this area is about 2.5 parts per million, while that in the samples indicated is 3.6. The amount of nitrogen in the two determinations is noticeably low. This may be due in part to the short term of storage afforded in the mill pond above Saxonville dam, but the more correct explanation is probably that the water which runs out of the restricted area below the reservoirs has little polluting material turned into it, except that of an indirect nature, and the only testimony which remains is the abnormal amount of chlorine. As far as the analyses show, the water from above Saxonville dam may be taken to represent roughly the character of the unpolluted Sudbury water. A comparison with the analyses of the water taken from points below may be fairly made upon this basis. Nos. 3 and 4 show clearly the effects of pollution from Saxonville, while 5, 6, 7, and 8 well represent the effects of oxidation, sedimentation, and dilution with fairly pure water from small tributaries. No. 8 shows in an instructive way the difference in the purifying action of those three agents during the cold season. Nos. 9–12 in Table 10 and 13–24 in Table 11 present no remarkable features, and merely indicate the continued effects of self-purification in a river which runs through a district sparsely populated. It is interesting to note that the amount of chlorine remains high, increasing as the points of pollution are passed, and thereafter being reduced in proportion to the dilution from tributary streams.

ASSABET RIVER.

The drainage area of this river is a narrow one, lying between the drainage basin of the Sudbury and that of the Nashua. The country is fertile and the affluent from sewage-disposal works at Westboro and the pollution at the village of Northboro all assist in contaminating the stream. The special report of the State Board of Health in 1895, in considering future sources of supply for the metropolitan district, contains the following statement:

> Owing to the polluting matters which enter the streams at Northboro, to the very large area of swampy land along the river between Northboro and the Boston and Albany Railroad, and to the disposal of the sewage of Westboro upon the banks of this section of the river (Assabet), it is not of suitable quality for water-supply purposes.

The analyses published at that time fully bore out this statement,

but since then the river has become more polluted. The annual report of the State board for the year 1900 contains the following analyses:

TABLE 12.—*Analyses of water from Assabet River.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	Place of collection.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.				
Feb. 27, 1901	Decided	5.0	0.520	0.204	0.002	0.280	4.3	60.0	16	2 miles above Northboro.
Aug. 15, 1900	Slight	5.4	.302	.100	.003	.000	5.2	53.0	18	Below Hudson.
Aug. 29, 1900	Decided	7.0	.110	.640	.001	.020	24.9	124.5	23	Do.
Feb. 27, 1901	do	3.3	.416	.256	.005	.300	15.9	80.5	18	Do.
Do	do	4.0	.336	.188	.005	.220	7.1	66.0	14	Below Gleasondale.
Aug. 15, 1900	do	3.0	.376	.140	.002	.000	6.7	53.5	11	Below Maynard.
Aug. 29, 1900	do	3.4	.425	.090	.003	.010	7.6	61.5	11	Do.
Feb. 27, 1901	do	3.5	.480	.288	.004	.200	7.1	70.5	16	Do.
Aug. 15, 1900	Slight	3.2	.388	.216	.007	.070	6.5	50.5	13	Near mouth.
Aug. 29, 1900	Very slight	2.4	.278	.138	.005	.040	7.8	57.5	13	Do.
Feb. 28, 1901	Slight	3.5	.308	.164	.004	.280	6.6	57.0	18	Do.
Feb. 27, 1901	do	3.5	.296	.230	.005	.280	5.9	63.0	16	Do.

CONCORD RIVER, BETWEEN CONCORD AND LOWELL.

Below Concord, the river slowly winds through a country of scanty population, without materially adding to the pollution which it bears along. The water perceptibly improves through the same agencies as are above noted in the case of the Sudbury, until it comes within the polluting influence of Lowell.

TABLE 13.—*Analyses of water taken at different points along Concord River.*

[Parts per million.]

Turbidity.	Color.	Ammonia.		Nitrogen as—		Chlorine.	Total residue.	Hardness.	Place of collection.
		Albuminoid.	Free.	Nitrites.	Nitrates.				
Very slight	3.2	0.286	0.102	0.004	0.030	6.4	53.5	16	Below North Bridge, in Concord.
Do	3.0	.250	.080	.003	.040	6.7	55.0	17	At Flint's bridge, in Concord.
Slight	3.4	.278	.158	.005	.330	6.3	63.5	17	Junction Sudbury and Assabet.
Very slight	11.0	.352	.060	.002	.130	5.2	59.0	16	Billerica.
Do	2.6	.224	.044	.001	.010	9.4	61.0	25	Above Billerica waterworks.
Do	2.0	.222	.040	.000	.010	5.9	54.0	14	North Billerica.
Do	2.0	.220	.018	.000	.010	5.9	52.0	14	Above Talbot's mill, Billerica.

NASHUA RIVER.

Nashua River rises in Worcester County, Mass., and flows in a northeasterly direction into New Hampshire, where it joins the Merrimac at Nashua. Above Lancaster, Mass., the river divides into the North and South branches, the former coming down from the northwest, the latter having traced a circuitous course in a general northeasterly direction. (See fig. 5.)

FIG. 5.—Nashua River drainage basin.

There are situated within the Nashua Basin 23 municipalities, exclusive of Nashua, at the mouth, some of which extend over across the divide into other watersheds. The total population, according to the Twelfth Census, is about 83,200, or neary 161 per square mile. This, however, does not fairly represent the conditions upon the river system, for upon many branches the country is sparsely settled. Large settlements are not numerous, and only three are of important size. Fitchburg, on the North Branch, has a population of 31,531; Leominster, a short distance below, is reported to have 12,393; and Clinton, the only important center on the South Branch, has 10,251 inhabitants

SOUTH BRANCH OF NASHUA RIVER.

The South Branch of the Nashua has a drainage area of 129 square miles, the topography being hilly and steep, affording admirable opportunities for storage. The upland branches, Quinepoxet and Stillwater, join to form the South Branch, bringing in the waters of a country of small population and affording a supply of excellent quality. Practically all of this upland area has been set aside by the Metropolitan Water Board for the conservation of a supply for Boston and vicinity. The river is intercepted by a mammoth dam, which will hold back the waters of one of the largest reservoirs ever constructed, at a point just above Clinton.

The waters of the reservoir will cover the present villages of Boyleston, West Boyleston, and Harrisville, and the work of effacing these places has already been carried forward. At the time of the first report on the project, in the year 1895, the population of the proposed restricted area of 118.23 miles was 61 per square mile. Since that time there has been practically no increase over the whole country, and recently the destruction of the villages above mentioned has caused a marked decrease. The completion of this work will effect a change in the quality of the water taken from this basin. The few points of pollution now existing there will be removed and storage in the new reservoir will improve the character of the water. Yet even now the supply which is taken from the river and carried through the aqueduct constructed across the eastern watershed to the Sudbury Basin is of excellent quality and will serve as a normal from which to consider the pollution in the lower reaches of the river. Reference to the map of normal chlorine, page 28, will show that the proportion for this country is 1.6 parts per million.

Quinepoxet and Stillwater rivers.—From the Massachusetts reports have been taken the following statements of analyses of waters gathered from the Quinepoxet and Stillwater rivers, the one at Holden and the other at Sterling:

TABLE 14.—*Analyses of water from Quinepoxet and Stillwater rivers.*

QUINEPOXET RIVER AT HOLDEN.

[Parts per million. Averages by years.]

Year.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1892	Slight	6.2	0.194	0.014	0.001	0.088	1.9	37.0	9
1893	do	7.2	.192	.004	.001	.044	2.6	37.5	9
1894	do	6.1	.214	.041	.001	.027	2.9	38.5	7
1895	Very slight to distinct.	7.7	.289	.020	.003	.090	2.6	44.7	9
1896	do	6.4	.250	.012	.000	.045	1.9	37.4	4
1897	Very slight to decided.	7.7	.275	.032	.001	.055	2.1	38.8	8
1898	Slight	6.2	.248	.030	.001	.037	2.1	34.7	8
1899	Very slight to decided.	4.8	.261	.028	.001	.046	1.9	36.5	5
1900	do	5.1	.277	.036	.002	.047	2.1	38.8	5

STILLWATER RIVER AT STERLING.

1892	None to slight.	4.4	0.131	0.001	0.000	0.072	1.3	33.8	9
1893	do	5.0	.147	.006	.001	.002	1.8	34.5	7
1894	do	4.5	.137	.008	.000	.017	1.8	32.0	8
1895	do	5.2	.179	.008	.000	.051	1.9	34.8	9
1896	Very slight to distinct.	5.0	.229	.016	.000	.035	1.6	33.2	7
1897	None to very slight.	6.6	.199	.013	.000	.037	1.7	34.7	8
1898	do	5.1	.158	.008	.001	.026	1.6	30.2	8
1899	Very slight	3.1	.177	.020	.000	.050	1.7	32.4	5
1900	None to very slight.	3.3	.156	.025	.001	.025	1.5	30.7	7

South Branch of Nashua River at Clinton.—Just below the dam which marks the beginning of the restricted area above described the South Branch passes the town of Clinton, and there meets with its first important pollution. Flowing through Clinton from the west, Coachlace Brook enters the main stream. The large plant of the Lancaster Woolen Company, employing over 2,000 hands, contributes sewage and manufacturing refuse into the South Branch, and a small portion of the town also drains into this stream. Until September 15, 1899, the sewage of Clinton and an enormous quantity of wool-washing waste and other refuse from the extensive works of the Bigelow Carpet Company were discharged into Coachlace Brook.

In Table 15 is set forth results of four analyses of water from Coachlace Brook, which was at that time the foulest stream in the Nashua Basin.

TABLE 15.—*Analyses of water from Coachlace Brook:*

[Parts per million.]

Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.		
Slight	3.5	0.620	2.280	0.056	0.180	10.0	96.5
Do	2.3	.520	2.200	.033	.330	9.5	89.0
Distinct	2.0	.710	1.720	.044	.200	9.9	94.5
Decided	4.0	.786	1.620	.200	.050	9.7	110.0
Average	2.9	.659	1.955	.083	.190	9.8	97.5

Character of water at Lancaster.—A short distance below this point is Lancaster, the place at which the North Branch enters. The quality of the water has been determined by a long series of analyses of samples taken at a point on the South Branch just above the confluence of the two rivers. The place was well chosen, for the water taken there shows the effect of the mixture of the water from Coachlace Brook and that running past the Lancaster mills, as above described.

TABLE 16.—*Analyses of water from South Branch of Nashua River above its confluence with North Branch at Lancaster.*

[Parts per million.]

Year.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	Number of analyses made.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.				
1895	Very slight to distinct.	5.3	0.238	0.167	0.008	0.114	3.4	46.6	14	16
1896	Distinct	4.5	.216	.094	.006	.134	3.5	47.2	16	12
1897	Very slight to distinct.	6.0	.257	.092	.004	.110	3.2	44.7	18	12
1898	Very slight to decided.	5.0	.269	.327	.010	.098	3.3	47.7	13	12
1899	Very slight to distinct.	4.5	.415	1.026	.018	.087	7.5	73.4	17	12
1900	Very slight to decided.	3.3	.346	.537	.020	.392	10.0	77.3	19	12
1901	Decided	3.3	.331	.314	.012	.405	8.1	78.4	19	12

NORTH BRANCH OF NASHUA RIVER.

The North Branch of the Nashua is a good power stream and has been utilized extensively. Its flow is regulated to some extent by a series of reservoirs, but in spite of this the flow is variable. The total area of the basin is 127 miles, and the population is greater than that on the South Branch. The communities of Leominster and Fitchburg contain 44,000 inhabitants; both places support extensive manufacturing industries, and the pollution from household sewage and factory wastes is extensive. There are, nevertheless, many points in the watershed above these towns where the water is of excellent quality. Among these are Scott reservoir, which supplies Fitchburg, and Morse and Haynes reservoirs above Leominster, analyses of which are recorded in Table 7.

Normal water.—Still farther up in the drainage area is the Ashburnham storage reservoir, which conserves a normal water of a character indicated in the following report of analysis, it being the average of nine samples:

TABLE 17.—*Analysis of water from Ashburnham storage reservoir.*

[Parts per million.]

Turbidity	"None" to "distinct."
Color	None.
Residue on evaporation	25.3
Free ammonia	.003
Albuminoid ammonia	.077
Chlorine	[a]1.3
Nitrates	.191
Nitrites	.001

Above Fitchburg.—Taking the waters of Scott, Haynes, Morse, and Ashburnham reservoirs as normal, let us descend to a point a short distance above Fitchburg, where the pollution is merely that from a few factories in the vicinity of West Fitchburg.

TABLE 18.—*Analyses of water from North Branch of Nashua River above Fitchburg.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
June 19	Very slight	3.8	0.170	0.002	0.001	0.050	1.4	33.5	5
August 1	do	4.5	.182	.008	.000	.010	1.6	32.5	5
August 29	None	3.9	.170	.010	.000	.050	1.8	31.5	5
September 26	Slight	3.8	.216	.008	.001	.030	2.3	26.5	5
October 23	None	4.2	.192	.012	.000	.020	2.3	42.5	8
November 28	do	6.0	.178	.022	.000	.070	1.8	35.0	10
December 26	Very slight	4.5	.130	.012	.001	.130	1.8	36.0	8
Average		4.4	.177	.011	.000	.051	1.9	33.9	7

[a] Normal.

Except for a slight increase in the amount of chlorine the above analyses do not differ significantly from those in the normal reservoirs above noted. This difference is, however, an important one and bears unmistakable evidence of the pollution above noted.

Below Fitchburg.—Below Fitchburg the character of the water undergoes a marked change, as is indicated by the following series of analyses of samples taken at a point just below the city. It will be observed that, although the evidences of pollution are clear, they do not indicate the extremely foul character which was apparent in the waters of Coachlace Brook, on the South Branch.

TABLE 19.—*Analyses of water from North Branch of Nashua River below Fitchburg.*

[Parts per million.]

Date of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1893	5.7	0.360	0.461	0.018	0.118	6.9	74.6	20
1894	5.6	.346	.634	.020	.152	7.5	73.9	19
1895	5.9	.423	.832	.010	.134	7.5	81.0	22
1896	4.8	.499	.677	.017	.151	7.4	81.5	20
1897	6.1	.420	.370	.007	.120	6.1	68.2	18
1898	5.1	.467	.435	.009	.117	4.8	60.0	16
1899	4.3	.657	.967	.009	.069	7.2	76.2	18
1900	3.9	.660	1.011	.010	.072	9.7	81.0	20

Below Leominster.—Descending farther we come to Leominster, at which place enters a polluted stream known as Monoosnoc Brook, the characters of which are shown by the following statement, which is the average of ten analyses made in 1899 and 1900.

TABLE 20.—*Average of ten analyses of water from Monoosnoc Brook.*

[Parts per million.]

Turbidity	Decided.
Color	7.5
Residue on evaporation	49.9
Free ammonia	.280
Albuminoid ammonia	.444
Chlorine	4.3
Nitrates	.071
Nitrites	.0075
Hardness	12

At Lancaster.—Another series of analyses appears to have been made, the water being taken from the North Branch at a point just above its confluence with the South Branch. This point is also well chosen, as the river carries all the pollution which has entered above save that which has been oxidized or deposited in the course of the stream. Analyses of the water here show just what is contributed by the North Branch to the Nashua River system.

The following record covers six years, and can therefore be accepted as indicative of the true character of the water:

TABLE 21.—*Analyses of water from North Branch of Nashua River, just above its confluence with the South Branch at Lancaster.*

[Parts per million.]

Date of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1895	5.1	0.269	0.282	0.019	0.236	7.7	69.6	19
1896	4.7	.293	.217	.019	.155	5.5	61.6	18
1897	5.4	.290	.285	.008	.150	4.2	52.9	15
1898	4.5	.268	.222	.013	.168	4.4	50.7	15
1899	3.6	.316	.540	.016	.132	6.0	63.8	16
1900	3.1	.322	.501	.022	.152	6.6	63.4	18

A comparison of the results in Table 21 with the analyses of water from the South Branch, Table 16, shows that until 1899 North Branch was the more highly polluted.

During the years 1895–1898, inclusive, the amounts of free ammonia, nitrates, and chlorine in South Branch water were approximately 50 per cent of those in North Branch. After 1898 there appears to be a decided change in the character of the water in South Branch; organic ingredients increased remarkably and reached a maximum in the year 1900. It is evident that unusual conditions arose to produce this result. A history of the work of the Metropolitan Water Board of Massachusetts upon the South Branch of Nashua River shows that in March, 1898, a large proportion of the run-off water in the basin of South Branch above Clinton was diverted for use in the metropolitan district. This water had, up to this time, been efficient in diluting the refuse and sewage discharged from Clinton, and its withdrawal was immediately apparent in the condition of the stream below. Coincident with this diversion there was in progress the preparation of Wachusett reservoir; old dams were removed, the surface of the country was stripped of vegetation, and large amounts of water were

turned into the stream from foundation-wall excavations. The result was that the water which flowed past Clinton was made extremely turbid, and must have carried along in solution, as well as in suspension, great quantities of organic matter. These conditions are entirely sufficient to account for the change in the character of South Branch water above its confluence with North Branch.

The unfavorable change in the character of the water in South Branch is only temporary. The beginning of an improvement took place late in the fall of the year 1899, when the sewage of Clinton and the manufacturing wastes of the Bigelow Carpet Company were diverted into newly constructed purification works. The completion of Wachusett reservoir will mark the end of the operations which have increased the organic constituents in the river water and South Branch will be restored to its former condition, or be greatly improved. Mr. F. P. Stearns, chief engineer of the Metropolitan Sewerage and Water Board, has expressed the belief that the above result will be reached in the fall of the year 1903, or early in the spring of 1904.

From Lancaster to Nashua, N. H.—We have now traced the pollution in the headwaters of the Nashua branches down to a point at which the main river takes its origin. From this point to Groton the river flows very sluggishly, and from Groton to a point 3 miles from its confluence with the Merrimac its fall is more rapid, becoming quite steep for the remainder of the course. From Lancaster to Nashua there is no settlement contributing important pollution. As the river sluggishly winds along its course it is increased in flow by other streams, notably the Squannacook at Ayer and the Nissitisset at Pepperell, so that when it reaches the latter place dilution, sedimentation, and oxidation have had an effect which may be readily seen by examining the following reports of analyses:

TABLE 22.—*Analyses of water from Nashua River at Groton and Pepperell.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	Place of collection.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.				
May 22, 1895	Decided	4.0	0.164	0.014	0.003	0.170	4.0	48.5	16	Groton.
Aug. 16, 1899	Slight	2.0	.264	.116	.014	.230	7.0	65.0	17	Pepperell.
Sept. 21, 1899	Very slight	2.7	.230	.054	.012	.150	8.2	67.5	20	Do.
Oct. 14, 1899	do	2.4	.236	.168	.004	.060	9.7	75.5	23	Do.
Mar. 15, 1899	Decided	4.2	.264	.332	.003	.110	6.4	68.5	23	Do.
July 16, 1900	Very slight	1.5	.200	.100	.005	.050	7.0	60.0	20	Do.
Aug. 21, 1900	Slight	2.3	.258	.234	.018	.100	9.2	65.0	20	Do.

Flowing ever more swiftly it passes into the State of New Hampshire and emerges at Nashua in the Merrimac. The average of 19 analyses made during the years 1887–88 appear below. The samples were taken at Mine Falls, above Nashua pollution.

TABLE 23.—*Average of nineteen analyses of water from Nashua River at Mine Falls.*

[Parts per million.]

Turbidity	Slight to decided.
Color	3.8
Residue on evaporation	45.8
Free ammonia	.029
Albuminoid ammonia	.187
Chlorine	[a] 2.9
Nitrates	.102
Nitrites	.003

OTHER TRIBUTARIES OF THE MERRIMAC.

Outside of the State of Massachusetts the character of the waters of the Merrimac drainage area is almost unknown. The New Hampshire laboratory of hygiene has not yet been established for a time sufficient to allow extensive investigations. It is probable that in due time this laboratory will complete the work which has been carried on by the State Board of Health of Massachusetts.

Piscataquog and Contotook rivers.—No analyses are available of the water of the Piscataquog or Contotook. It is safe to assert that neither stream is polluted to any extent, for there are no important settlements in the valleys. The population in the basin of the Contotook is only 31.4 per square mile.

Lake Winnepesaukee.—The water of Lake Winnepesaukee has been analyzed by the Massachusetts State Board of Health for the purpose of determining its fitness as a source of supply for the metropolitan district. The average is included in Table 7.

Pemigewasset River.—The Pemigewasset Valley, which lies at the head of the Merrimac system, has a population of 17 per square mile. No sewerage systems enter the river, nor are there any large centers of population. The supply of water to the Merrimac is therefore pure and abundant. The only available analysis has been kindly furnished by Mr. H. E. Barnard, chemist of the New Hampshire laboratory of hygiene. The place of collection was at Campton Village, at the extreme southern end of the basin. It therefore fairly represents the character of the water furnished by the Pemigewasset drainage area to the Merrimac.

[a] Chlorine 1.4 above normal.

TABLE 24.—*Analysis of water from Pemigewasset River at Campton, N. H.*

[Parts per million.]

Appearance.			Ammonia.				Chlorine.	Nitrogen as—		Hardness.
Turbidity.	Color.	Total residue on evaporation.	Free.	Albuminoid. Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
None	4.0	34	0.016	0.094	.....	.....	0.637	0.100	0.100	.....

POLLUTIÓN OF MERRIMAC RIVER AT MANCHESTER, NASHUA, LOWELL, LAWRENCE, AND HAVERHILL.

Having considered the characteristics of the water in the tributaries which have received attention from analyses, let us review the work which has been done in the Merrimac proper and show, as closely as possible with the data at hand, how each tributary affects the river; also the changes due to the extensive pollution which arises from the cities along the bank.

Manchester.—We have said that the upper part of the Merrimac area is sparsely settled, and that such analyses as are available show that the water is pure. From the Contotook, Pemigewasset, and Winnepesaukee drainage basins there is delivered into the Merrimac a great volume of water, which is increased by the numerous smaller tributaries which enter all along the course. It is not likely that it changes greatly in character until it reaches Manchester, N. H., an important manufacturing city of 56,987 inhabitants. Sewage and manufacturing wastes are poured directly into the river, and, although there are at hand no analyses to show the exact condition of the wate , it is certain that the change is marked.

Nashua.—Sixteen miles below, at the city of Nashua, a series of analyses has been furnished by Mr. Barnard which shows the effect of Manchester pollution after it has been carried along for the above distance. It is at this point that the abundant flow of Nashua River enters the Merrimac, dilutes still further the Manchester pollution, and renders the sewage from Nashua, a city of 23,898 inhabitants, less damaging than it would be under conditions not so favorable.

TABLE 25.—*Average of nineteen analyses of water from Merrimac River at Nashua.*

[Parts per million.]

Appearance.			Ammonia.				Chlorine.	Nitrogen as—		Hardness.
Turbidity.	Color.	Total residue on evaporation.	Free.	Albuminoid. Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
Slight	3.4	50.1	0.014	0.153	.....	.....	1.5	0.074	0.002	6.0

Lowell.—Leaving Nashua, the river crosses the State line, and when it reaches a point opposite the old water intake at Lowell it is of a quality shown in the following analysis:

TABLE 26.—*Analyses of water from Merrimac River above Lowell.*

[Averages by years, monthly samples. Parts per million.]

Years.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1888	3.0	0.148	0.016	0.002	0.099	1.6	34.2	.....
1889	2.8	.149	.018	.002	.071	1.4	29.5	.....
1890	3.0	.128	.014	.001	.111	1.3	35.7	14
1891	2.9	.129	.017	.001	.137	1.3	34.3	12
1892	3.9	.141	.021	.001	.092	1.4	36.1	13
1893	3.3	.149	.026	.001	.082	1.0	33.9	11
1894	3.5	.135	.024	.001	.063	1.8	35.5	11
1895	4.1	.187	.029	.001	.066	2.1	38.4	12
1896	4.0	.167	.024	.001	.070	1.7	34.7	10
1897	5.1	.177	.030	.001	.067	1.5	35.4	10
1898	4.2	.173	.026	.001	.048	1.7	35.3	10
1899	2.7	.287	.050	.002	.060	1.8	36.0	9
1900	2.7	.297	.052	.002	.047	1.9	35.5	11

The water represented in the series of analyses above set forth was formerly used in its raw state as the principal water supply for the city of Lowell. The history of that municipality during this period furnishes to the world one of the clearest illustrations of the cost of water pollution extant, and it stands among epidemiologists as one of the classical examples of disease production through polluted water supply. No history of typhoid fever is complete without an account of the Lowell epidemic. For years the typhoid rate was abnormal, but little attention was given to it until the year 1890, when there occurred from September of that year to January, 1891, a series of 550 cases. Prof. William T. Sedgwick, in a remarkable investigation, traced the origin of the epidemic to a few individuals who, while in the prodromal stage of typhoid fever, had polluted a small brook which enters the Merrimac a short distance above Lowell.

The pecuniary damage caused by polluted water throughout all the years in which the Merrimac was used as a source of supply will never be even approximately estimated. In the epidemic of 1890 alone there was a loss of 92 lives. In addition to this there was the expense incident to the care of 550 cases of the disease and the temporary loss of productiveness of all those who escaped death. The greater part

of this drain upon the resources of the community was without a shade of justification; it might have been prevented by the exercise of municipal decency. After the lesson had been learned, the city of Lowell was obliged to add to the total expense by constructing a new supply, the cost of which will be borne by generations yet unborn.

As the Merrimac passes by Lowell its burden of sewage is increased by the addition of wastes from 95,000 persons and from enormous mills and factories.

Lawrence.—Flowing 9 miles farther the river reaches the city of Lawrence, and there, opposite the intake of the works, the water has a character denoted by the following series of annual averages, each average being the result of monthly analyses:

TABLE 27.—*Analyses of water from Merrimac River above Lawrence.*

[Parts per million.]

Year.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1888	3.0	0.180	0.026	0.002	0.094	1.8	36.8	------
1889	3.0	.176	.030	.003	.072	1.7	30.9	------
1890	3.3	.166	.046	.001	.089	1.7	31.9	16
1891	2.7	.152	.040	.001	.110	1.8	37.9	13
1892	4.3	.181	.042	.001	.105	1.8	41.2	14
1893	4.2	.181	.057	.002	.081	2.0	38.6	11
1894	3.7	.167	.062	.001	.063	2.3	37.0	12
1895	5.1	.249	.064	.002	.071	2.8	43.4	14
1896	4.2	.220	.068	.003	.087	2.4	39.8	12
1897	5.6	.228	.049	.001	.067	2.0	38.4	11
1898	4.5	.212	.050	.003	.058	2.2	39.0	11
1899	2.9	.232	.088	.003	.056	2.4	39.9	10
1900	3.0	.224	.089	.002	.060	2.5	39.6	11

The history of the Lawrence water supply and the consequences of its use closely resemble those already described at Lowell, and, indeed, the account of the events in the two cities is generally combined. For years the raw water from the Merrimac was pumped into the Lawrence mains. Following the discharge of typhoid-infected stools from the sewers at Lowell there arose a widespread epidemic in the lower city. In Lawrence the source of supply was not changed, but the first sand filter in the country was established at a cost of $65,000. Through this filter the water of Lawrence is now drawn at an annual expense of $8,000 or $9,000, the result being that the typhoid-fever rate in the city has been considerably lowered.

A comparison of the water after it has been passed through this filter with that in the river is instructive. For this purpose the following analyses are presented, each being the average of 12 monthly samples:

TABLE 28.—*Analyses of the effluent of the Lawrence filter.*

[Parts per million.]

Year.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1894	3.9	0.094	0.103	0.002	0.309	3.0	61.0	28
1895	5.0	.108	.146	.001	.274	3.1	59.5	27
1896	4.0	.099	.121	.004	.319	2.5	54.3	24
1897	5.6	.108	.123	.002	.317	2.5	51.7	20
1898	4.3	.090	.107	.001	.324	2.6	46.6	19
1899	2.7	.089	.087	.001	.205	2.8	44.4	16
1900	2.8	.108	.123	.001	.173	2.7	43.0	15

TABLE 29.—*Increase in amount of impurities in Merrimac River water from a point above Lowell to Lawrence, as determined by regular monthly examinations in different years.*

[Parts per million.]

Year.	Color.	Nitrogen as—				Chlorine.	Total residue	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1887–1889	0.1	0.027	0.007	0.000	[a]0.003	0.026	2.3	.....
1890	.5	.023	.016	.000	[a].020	.280	6.2	2
1891	[a].2	.023	.021	.000	[a].030	.350	2.9	1
1892	.6	.027	.019	.000	[a].013	.390	4.8	0
1893	.9	.032	.031	.001	[a].002	.350	4.7	0
1894	.2	.032	.028	.000	.000	.490	1.5	1
1895	1.1	.063	.022	.001	.005	.630	5.2	1
1896	.2	.053	.034	.002	.017	.700	5.1	2
1897	.6	.051	.019	.000	.000	.500	3.0	1
1898	.3	.039	.024	.002	.010	.440	3.7	1
1899	.2	.045	.038	.001	[a].004	.590	3.9	1
1900	.3	.027	.037	.000	.011	.550	4.1	0

[a] Decrease.

At Lawrence the sewage from 63,000 persons and extensive manufacturing wastes are poured into the Merrimac. Thence the river flows 8 miles to Haverhill.

Haverhill.—Above Haverhill there were, from July to November, 1900, five samples taken, the reports of analyses being as follows:

TABLE 30.—*Analyses of Merrimac River water above Haverhill.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
July 17	Slight	2.3	0.288	0.192	0.004	0.010	3.9	46.5	13
Aug. 21	Decided	1.5	.316	.144	.008	.050	3.9	44.0	16
Sept. 18	Slight	1.5	.328	.272	.009	.020	4.8	50.0	13
Oct. 30	do	3.4	.360	.296	.010	.100	4.4	53.5	14
Nov. 20	Decided	6.5	.328	.144	.003	.080	3.3	53.0	16
Average		3.0	.324	.210	.007	.052	4.1	49.4	14

Haverhill sewage is discharged into the Merrimac. This city has a population of 31,175. Analyses of the water from the river, collected a short distance below the city, are reported by the State Board of Health as follows:

TABLE 31.—*Analyses of Merrimac River water below Haverhill.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
July 17	Slight	2.0	0.324	0.284	0.007	0.010	4.2	44.0	14
Aug. 21	Decided	1.5	.276	.220	.010	.020	3.7	45.0	17
Sept. 18	Slight	2.3	.375	.265	.017	.040	5.7	55.0	16
Oct. 13	Decided	3.5	.360	.264	.011	.090	4.4	54.0	11
Nov. 20	do	6.6	.340	.136	.004	.120	3.2	53.5	14
Average		3.2	.335	.311	.010	.050	4.2	50.3	12

BLACKSTONE RIVER.

COURSE, CHARACTER, AND UTILIZATION OF THE STREAM.

Blackstone River is a small stream which rises in Worcester County, Mass., and flows in a southeasterly direction, passing over the State line into Rhode Island and emptying into the Providence River at Providence. Its drainage area covers about 458 square miles. At the source the elevation is 438 feet above mean tide and as its course is about 43 miles long its fall must be somewhat more than 10 feet per mile. It is obvious that such a river, so accessible, and in the midst of a populous country, must have unusual value as a source of power. This fact has long been recognized and the stream has been thus utilized, the natural facilities being enhanced by the development of every accompaniment known to be of use in a river of this character. Probably no stream in the United States has been so effectively harnessed and brought into subjugation; milldams have been erected at favorable points, compensating reservoirs have been constructed, and ponds and lakes have been raised in order that the flow may be regulated to meet the demands of manufacturing. The result is that though the river is derived from a watershed which has been extensively deforested, and, under ordinary circumstances it would be subject to floods and variation in flow, its water is seldom allowed to fall below a certain minimum because of the judicious management of the conserved water during dry seasons. The great resource of this stream is, therefore, its water power, and it has been said with authority that the value of this interest is proportionately greater than that found in any other stream in the United States.

POPULATION OF THE BASIN.

Population.—The Blackstone River (see fig. 6) is formed by the junction of Kettle and Mill brooks in the southern part of the city of Worcester. These two brooks drain small parts of the towns of Holden and Leicester, as well as Worcester. The other Massachusetts towns in the basin are Auburn, Millbury, part of Shrewsbury, Grafton, Upton, Sutton, Northbridge, Hopedale, Mendon, Douglass, Uxbridge, and Blackstone, representing a population of about 157,000, or 604 per square mile. In the State of Rhode Island the river drains the municipalities of North Smithfield, Burrillville, Gloucester, Woonsocket, Lincoln, and Cumberland, having a combined population of 56,267.

This large population is mostly in the northern part of the drainage area, at Worcester, Mass., which has a population of 118,421. The population per square mile therefore decreases as the mouth of the river is approached. This fact was well expressed in the report of the Massachusetts Board of Health in 1890, as follows:

TABLE 32.—*Population in drainage basin of Blackstone River.*

	Locality.	Distance below discharge of Worcester sewage.	Drainage area (square miles.)	Population, estimated (1888).	Population per square mile.
		Miles.			
1	At the Quinsigamond Iron and Wire Works	0	63.0	----------	----------
2	At the first bridge below Quinsigamond village	1	63.9	77,500	1,213
3	At the dam of the Cordis Co., Millbury	5	77.9	----------	----------
4	At the upper dam of the Calumet Woolen Co., Uxbridge	17	145.9	90,900	623
5	At the Middleville dam, Blackstone	24	258.1	102,800	398
6	At the dam of the Blackstone Manufacturing Co., Blackstone	26	260.3	----------	----------

Since the collection of the facts in the table the city of Worcester has grown faster than the lower towns in the valley, making the conditions above set forth even more extreme.

FIG. 6.—Blackstone River drainage basin.

NORMAL WATER IN THE BASIN OF THE BLACKSTONE.

Normal water in the basin of the Blackstone has been found at the head of Kettle Brook, Paxton, Lynde Brook storage reservoir in Leicester, and Tatnuck Brook storage reservoir in Holden.

TABLE 33.—*Analyses of normal water in Blackstone Basin.*

LYNDE BROOK STORAGE RESERVOIR.

[Parts per million, averages by years.]

Year.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1888	2.4	0.151	0.037	0.001	0.065	1.4	26.4	----
1889	2.4	.167	.030	.001	.053	1.5	25.4	----
1890	2.1	.132	.026	.001	.078	1.4	30.7	9
1891	2.4	.126	.045	.001	.074	1.2	28.3	7
1892	2.5	.139	.038	.000	.105	1.5	29.9	8
1893	2.6	.162	.036	.001	.066	1.5	26.6	6
1894	3.6	.139	.055	.000	.103	1.8	33.7	12
1895	3.2	.161	.033	.000	.116	2.0	36.3	12
1896	2.9	.158	.035	.000	.054	1.8	29.5	8
1897	4.4	.191	.068	.001	.087	1.8	33.1	8
1898	3.1	.156	.030	.001	.059	2.0	32.4	8
1899	2.0	.147	.030	.000	.031	1.2	24.9	4
1900	2.3	.176	.043	.000	.039	1.4	29.2	7
KENT RESERVOIR, KETTLE BROOK.								
1898	3.6	0.176	0.012	0.001	0.042	1.6	32.0	8
1899	2.7	.239	.047	.001	.037	1.3	32.5	7
1900	3.2	.213	.037	.001	.064	1.7	32.0	8
TATNUCK BROOK RESERVOIR.								
1888	1.7	0.157	0.012	0.001	0.043	1.2	22.3	----
1889	1.9	.143	.003	.001	.031	1.2	20.4	----
1890	1.7	.141	.007	.001	.078	1.3	26.8	9
1891	1.7	.143	.024	.001	.077	1.1	23.0	4
1892	2.0	.142	.012	.000	.067	1.2	25.2	5
1893	3.5	.182	.020	.000	.049	1.4	24.5	5
1894	2.0	.151	.010	.000	.032	1.6	22.7	4
1895	2.1	.173	.012	.000	.068	1.8	23.3	5
1896	1.7	.142	.008	.000	.034	1.5	20.0	4
1897	2.1	.155	.007	.000	.054	1.6	21.2	5
1898	2.2	.141	.006	.000	.020	1.6	22.4	5
1899	1.1	.136	.013	.000	.016	1.2	20.0	3
1900	1.5	.186	.026	.000	.023	1.2	22.7	3

POLLUTION IN BLACKSTONE RIVER.

The Blackstone is the most polluted river in New England; its name has become synonymous with filth. The headwaters of a river system are usually free from pollution, but in this case the opposite is true. The sewage from the city of Worcester befouls the river almost at its source, and thereafter throughout its whole extent the Blackstone is a damaged resource to the country. Such is the accumulation of filth in the mill ponds that from some of those near Worcester there arise odors that are detrimental to comfort and realty, if not to health. The use of its water in boilers has long been abandoned, and it can not be used in the manufacture of light-colored cloths.

Worcester sewage.—The sewage of Worcester, consisting of the usual city waste and an enormous amount of manufacturing refuse, a large part of which is acid from the steel manufactories, is turned from the sewers into Mill Brook. The quantity is sufficient at times to give to the waters of the Blackstone River an acid reaction.

The water of Mill Brook above the point of sewage discharge has not been regularly examined, but it is known to be of a quality characteristic of a stream flowing through a country of considerable population, and approaching in some degree the character of the normal waters above set forth. After being polluted with the Worcester sewage the water of Mill Brook is of a vile character, as is shown in the following table of averages of monthly analyses for the years 1888–1900.

TABLE 34.—*Analyses of water from Blackstone River below mouth of Mill Brook and above outlet of sewage works.*

[Parts per million.]

Year.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1888	6.4	1.040	2.112	0.029	0.370	12.1	----	----
1889	7.6	1.198	2.841	.024	.235	10.6	----	----
1890	8.2	1.024	1.800	.014	.367	10.3	----	----
1891	8.0	1.563	3.340	.032	.333	17.3	135.4	46
1892	7.1	1.262	2.530	.061	.312	18.4	162.8	49
1893	6.8	.603	1.429	.012	.180	10.4	179.5	45
1894	8.6	.570	.739	.006	.195	8.8	171.7	37
1895	8.4	.374	.507	.007	.175	8.6	134.0	29
1896	7.5	.486	.759	.010	.187	10.1	126.9	29
1897	9.4	.533	.715	.015	.151	7.7	176.2	29
1898	5.0	.557	.762	.011	.167	8.3	135.2	35
1899	2.6	.751	1.921	.010	.109	12.0	253.3	97
1900	1.8	.602	1.141	.011	.102	8.3	194.9	62

For years the city of Worcester has converted Mill Brook into an open sewer, and up to June 25, 1890, the contents were discharged directly into Blackstone River. At that time, however, a chemical precipitation works was completed by the city, and by means of a diverting dam the whole flow of Mill Brook, except during seasons of freshet, was carried across to a series of tanks, six in number, each being 100 feet long, 66.76 feet wide, and 7 feet deep. The capacity of these tanks for the treatment of sewage, according to the process adopted, was 6,000,000 gallons daily. In the year 1883 ten more tanks were added to the original six, which gave to the disposal works a nominal capacity of 15,000,000 gallons per day.

The treatment of sewage was first as follows: After being screened it was mixed with chemicals, and, passing through a mixing channel, it fell into the precipitation tanks, discharging from the first to the second, and so on through the whole series, finally being poured into the Blackstone River. The chemicals used were lime and sulphate of alumina, the former being required in large quantities when the sewage was greatly impregnated with iron. After the enlargement of the works in 1893 the process was changed slightly, the object being to secure a more thorough mixture of chemicals with the sewage before it passed into the precipitation tanks. During the year ending November 30, 1901, 3,564.7 million gallons of sewage were received at the disposal works, of which 3,133.8 million gallons were treated chemically and the remainder used for experimental work in connection with new processes of sewage disposal. The total cost of this treatment was $12.20 per 1,000,000 gallons. The chemical precipitation of sewage at Worcester is not, however, successful from the standpoint of river purification, and very little if any benefit has been apparent in the river throughout all the years during which this great expenditure has been incurred by the city. Finally the legislature of the State enacted a law requiring the city to dispose of its sewage by some other method, and experiments are now being conducted to determine a method which will effect a more satisfactory purification of Blackstone River.

Below sewage-disposal outlet.—The next recorded point of examination of the Blackstone is below the sewage precipitation works. The point of collection of the samples is nearly a mile below the mouth of Mill Brook and a considerable distance below the outlet of the precipitation works, so that the effluent has had ample opportunity to become thoroughly mixed with the river water. The following is a list of annual averages of monthly examinations during the period 1888–1900.

TABLE 35.—*Analyses of water of Blackstone River below Worcester sewage-disposal outlet.*

[Parts per million.]

Year.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1888	6.4	1.040	2.122	0.029	0.370	12.1		
1889	7.6	1.198	2.894	.024	.235	10.6		
1890	7.4	1.177	2.253	.016	.381	12.6		
1891	8.0	1.303	4.080	.031	.358	19.1	156.2	46
1892	5.3	1.442	3.633	.033	.278	22.1	193.5	72
1893	7.4	1.447	3.757	.070	.369	19.8	256.5	74
1894	6.0	1.309	4.228	.047	.316	21.3	257.5	79
1895	7.9	.840	2.298	.040	.347	15.2	191.4	58
1896	4.0	.930	2.645	.071	.356	19.1	242.8	83
1897	7.5	.843	2.447	.047	.300	13.3	199.4	54
1898	4.9	.725	2.260	.072	.264	13.0	194.1	66
1899	3.0	1.337	3.908	.053	.176	23.7	324.8	120
1900	2.5	1.249	4.430	.145	.110	21.3	224.7	73

Comparison of the analyses in Tables 34 and 35 shows clearly that, in spite of the so-called sewage purification carried on at Worcester at so great an expense, Blackstone River is in far worse condition below the sewage outlet than above. The amounts of free ammonia, nitrites, and chlorine at the lower sampling point are considerably greater than above the outlet of the purification works. In addition to this there are unmistakable evidences that the amount of objectionable matter from the outlet is increasing from year to year, while the conditions above constantly improve.

Uxbridge.—Again there appears a record of examinations of samples taken from the river at the upper dam of the Calumet Woolen Company at Uxbridge, 17 miles below the city of Worcester. The analyses were made monthly during the period 1888–1900, but in Table 36 the results are made up into yearly averages, as in the preceding tables, 34 and 35.

TABLE 36.—*Analyses of water from Blackstone River at Uxbridge.*

[Parts per million.]

Year.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1888	4.5	0.284	0.979	0.008	0.322	6.1		
1889	2.8	.300	.992	.009	.253	6.0		
1890	2.5	.214	1.168	.006	.272	6.6		
1891	2.7	.272	1.674	.008	.396	7.7	83.2	28
1892	2.1	.222	2.113	.007	.326	8.2	85.9	28
1893	4.0	.256	1.603	.029	.424	10.0	94.5	32
1894	5.1	.242	1.372	.032	.460	12.2	108.0	40
1895	6.4	.315	1.081	.037	.439	10.5	105.6	39
1896	4.2	.308	1.209	.054	.405	10.9	107.7	42
1897	5.9	.298	1.126	.035	.481	10.4	103.1	38
1898	5.8	.305	.818	.046	.360	8.4	87.2	32
1899	2.6	.374	2.298	.078	.331	15.9	140.6	56
1900	2.7	.351	2.122	.039	.359	13.8	114.3	42

It will be seen that sedimentation, dilution, and oxidation have worked improvement in the water by the time it has traversed the 17 miles, although the process during late years does not appear to be as effective as formerly. It requires only a glance to perceive that the pollution of the Blackstone is still enormous. Be it remembered, too, that, apart from the pollution at Worcester, the numerous mills along the course of the stream and the large number of employees there engaged contribute a great quantity of sewage and foul industrial waste, which of itself would be damaging to the river. Therefore the comparison of the two sets of analyses above given does not furnish an idea of the normal self-purifying ability of the river, for it is more than probable that there would appear a greater decrease in the amount of organic matter if it were not for the constant introduction of new pollution.

At Millville.—Down the river, nearly to the State line at Millville, town of Blackstone, a series of analyses similar to the one at Uxbridge has been carried on for thirteen years. This point is 24 miles from the Worcester outlet and the water is not objectionable in odor. Still, as the following analyses show, the water is polluted.

TABLE 37.—*Analyses of water from Blackstone River at Millville.*

[Average by years, in parts per million.]

Year.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1888	4.7	0.253	0.444	0.005	0.242	4.4	.....	.....
1889	3.8	.277	.450	.004	.160	4.3	.....	.....
1890	3.4	.211	.587	.004	.240	4.6	.....	.....
1891	3.2	.293	.807	.005	.275	5.5	60.5	19
1892	3.5	.249	.896	.004	.218	5.4	60.3	18
1893	4.0	.288	.899	.008	.289	6.6	62.3	20
1894	4.9	.219	.528	.008	.232	7.3	63.7	25
1895	5.8	.253	.501	.016	.278	7.4	74.7	27
1896	4.0	.248	.549	.018	.347	7.6	73.4	28
1897	5.3	.262	.528	.014	.332	7.3	70.7	26
1898	5.5	.256	.456	.016	.222	6.1	64.3	23
1899	2.8	.267	.985	.029	.220	8.8	89.5	32
1900	3.6	.288	1.194	.023	.272	9.3	83.2	29

In Rhode Island.—As Blackstone River passes out of the State of Massachusetts, it comes within the polluting influence of Woonsocket, R. I., a city of 28,000 inhabitants, situated a short distance south of the State line. From this point to its outlet in Providence it flows through a thickly settled country, which, while it contributes no large amount of raw sewage to the river, does not, nevertheless, permit so extensive a purification of its water as might be effected in a country having a smaller population.

The State of Rhode Island, through its board of health, has attempted to supplement the Massachusetts work by making periodical analyses of the water of the river at two different points—one at Albion, a short distance below Woonsocket, and the other at Valley Falls, nearer Providence. The results of these analyses are given in Table 38.

TABLE 38.—*Analyses of water from Blackstone River at Albion and Valley Falls, R. I.*

ALBION.

[Average by years, in parts per million.]

Year.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1894	0.235	0.156	0.040	0.800	11.0	75	21.7
1895	.260	.127	.....	.560	10.5	81	21.3
1896	.220	.204	.030	.780	.9	72	16.0
1897	.220	.223	.030	.650	7.7	75	14.0
VALLEY FALLS.							
1894	0.261	0.117	0.070	0.824	12.0	66.5	17.6
1895	.201	.139	.070	.500	10.8	69.0	22.4
1896	.200	.196	.070	.070	.9	85.0	16.0
1897	.220	.215	.040	.070	.8	74.0	15.0

The results expressed in Table 38 do not inspire confidence in their accuracy, and it is highly probable that the tables presented in the report of the State Board of Health for 1897 are typographically incorrect. On comparing the results with those taken from the Massachusetts reports it will be seen that the nitrites are enormously high, averaging greater than the amounts found below the Worcester sewage outlet. It is extremely unlikely that these results are correct, because of the fact that the water shows decided improvement as it flows from Worcester town to the Rhode Island line, and south of that there is no increment of sewage which would by any means give to the nitrites the enormous figure which appears in the above analyses. The chlorine determinations, too, show improbable fluctuations.

On the other hand, the amounts of free and albuminoid ammonia, which would necessarily fluctuate to some extent at least with the nitrites and nitrates, do not appear excessive.

CONNECTICUT RIVER BASIN.

NATURAL RESOURCES.

Course and drainage area.—The Connecticut is the largest river in New England. From its source in the Connecticut lakes in the extreme northern part of New Hampshire to its mouth in Long Island Sound the course of the river measures 375 miles. The drainage area is long and narrow, being from 40 to 60 miles in width and covering 10,924 square miles (see fig. 7). The character of the country

varies from the rolling surface common to Massachusetts to the hilly or mountainous country of New Hampshire and Vermont. The rocks are granite, gneiss, syenite, and mica, intersected by dikes of trap and red sandstone. Along the course of the river in Massachusetts and Connecticut there are rich alluvial deposits, but for the most part the basin of the Connecticut is covered by surface drift. Lakes are abundant on most of the branches, and the flow of the main river is fairly steady.

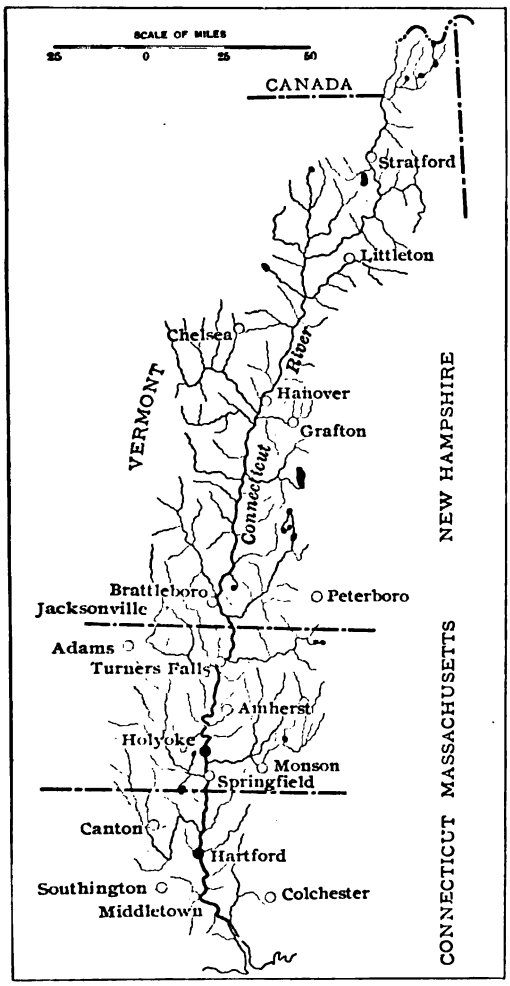

FIG. 7. -Connecticut River drainage basin.

The course of the Connecticut is varied. From its source for a distance of 200 miles downstream the river contains many falls and rapids, the last one being at Bellows Falls, Vt. Below this place the fall in the stream is much less, yet the pitch is sufficient to give the water a fairly good flow. Throughout the extent of the river below Bellows Falls the course of the river is broken by falls in three places, Turners Falls and Holyoke, Mass., and Windsor Locks, Conn. The power developed at Holyoke is the largest in the country, except that at Niagara.

Transportation. — The river has considerable importance in the lower end as a means of transportation. Navigation extends 30 miles from the mouth up to Hartford, and small boats may ascend, by means of Windsor Locks, as far as Holyoke. Travel, however, above Hartford is insignificant, while even in the lower stream large vessels have difficulty in low tide.

Power.—As a source of power the value of the Connecticut is enormous. The main river, with a total fall of 2,038 feet, has been largely utilized, but there remain possibilities for further development which,

if advantage were taken of them, would make the Connecticut one of the most valuable streams in the world. The tributaries have been developed extensively, and the possibilities for the future are promising.

In the following table, taken from Water-Supply and Irrigation Paper No. 44, there is presented a detailed statement of the altitude and fall per mile at different points along the river:

TABLE 39.—*Fall of Connecticut River.*

Locality.	Distance from mouth.	Height above sea.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
Mouth	0	0	
Hartford	50	0	
Foot of Enfield Rapids	60	6	0.6
Top of Enfield dam	66	38	5.3
Top of Holyoke dam	84	98	3.3
Fitchburg Railroad crossing	115	109	.35
Top of Turners Falls dam	120	173	12.8
Mouth of Ashuelot River	136	206	2.1
Westmoreland	159	219	.6
Foot of Bellows Falls	170	234	1.4
Head of Bellows Falls	170	283	
Beaver Meadows, Charlestown	181	289	.5
Windsor	196	304	1.0
White River Junction	209	339	2.7
Ledyard bridge, Hanover	213	375	9.0
Oxford	230	380	.3
Wells River	255	407	1.1
Foot of McIndoes Falls	262	432	3.6
Lower Waterford	273	643	19.2
Head of Fifteenmile Falls	285	830	15.6
North Stratford	312	885	2.0
West Stewartstown	344	1,035	4.7
Connecticut Lake	361	1,618	34.3
Second Lake	369	1,882	15.5
Third Lake	375	2,038	26.0

The following table contains a statement of the total utilized horsepower and the drainage area of the most important tributaries of the Connecticut.

TABLE 40.—*Drainage area and utilized horsepower on the Connecticut River tributaries.*

Tributary.	Horse-power utilized.	Drainage area.	Tributary.	Horse-power utilized.	Drainage area.
		Sq. miles.			*Sq. miles.*
Salmon River	1,432	150	Ottaquechee River	1,723	192
Hockanum River	3,957	79	Mascomy River	1,576	190
Little River	555	76	White River	2,714	623
Farmington River	8,856	584	Ompomponoosuc River	493	123
Scantic River	1,122	118	Waits River	596	156
Westfield River	3,910	514	Lower Ammonoosuc River	2,526	388
Chicopee River	4,044	706	Wells River	628	94
Mill River	1,161	58	Passumsic River	4,724	485
Deerfield River	4,352	646	Johns River	168	86
Millers River	8,172	369	Israels River	974	129
Ashuelot River	3,964	422	Upper Ammonoosuc River	548	252
West River	1,947	363	Nulhegan River	240	132
Williams River	361	103			
Black River	2,132	152			
Sugar River	3,176	272			

FLOW.

The flow of the river has been carefully measured and a concise statement appears in Part IV of the Twentieth Annual Report of the United States Geological Survey, page 47.

TABLE 41.—*Flow of the Connecticut River at Holyoke during the years 1880–1898, inclusive.*

[Drainage area, 8,660 square miles.]

Year.	Maximum.	Minimum.	Mean.	Run-off.	
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft. per sq. mi.*	*Inches.*
1880	44,100	300	8,343	0.96	12.89
1881	49,050	450	9,818	1.13	15.53
1882	45,000	250	10,018	1.14	15.40
1883	68,300	250	8,107	.94	12.70
1884	71,900	500	13,084	1.51	20.46
1885	63,950	2,950	12,635	1.46	19.65
1886	80,150	550	11,387	1.31	17.73
1887	85,500	3,300	14,329	1.65	21.32
1888	99,750	1,100	17,320	2.00	27.15
1889	37,650	1,350	13,903	1.59	21.50
1890	46,750	550	15,556	1.78	24.12

TABLE 41.—*Flow of the Connecticut River at Holyoke, etc.*—Continued.

Year.	Maximum.	Minimum.	Mean.	Run-off.	
	Sec.-ft.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft. per sq. mi.*	*Inches.*
1891	67,300	900	13,190	1.51	21.48
1892	63,100	1,800	12,273	1.48	20.15
1893	94,350	750	10,295	1.19	16.19
1894	43,300	150	8,397	.97	13.17
1895	115,000	350	10,314	1.20	16.19
1896	112,050	450	12,394	1.43	19.41
1897	75,350	1,300	15,373	1.78	24.17
1898	76,150	600	13,844	1.60	21.70

Water supply.—Although a comparatively small part of the drainage area of the Connecticut has been set apart and developed as a source of water supply, the value of the resources within its basin are readily apparent. None of the cities along the main stream pump their supply from the river direct, but in the areas of the tributaries numerous reservoirs have been constructed from which are obtained water supplies of excellent quality. These will be taken up in the discussion of the different branches.

Ice.—The ice values in the Connecticut system are extensive. The same statements that were made in connection with this subject in the discussion of the Merrimac apply here. The main river has not been used largely as a source of ice supply. That it would be more acceptable than some rivers, as the Hudson, Kennebec, and Penobscot, which have been largely developed in this direction and yield enormous amounts annually, is very probable, yet it is the practice of the consumers in the Connecticut Valley to refuse to accept ice from the main stream. Therefore the small streams, ponds, and lakes within convenient distances from each municipality have been utilized. There is no estimate of the value of the ice crop in the Connecticut basin.

Character of water.—The character of water in the main river is of course largely determined by that from the tributaries feeding it, and as the water in the latter varies widely in different regions, that in the Connecticut proper is dependent upon the distance of a given sampling point from the confluence of a normal or a polluted branch. Below the entrance of a tributary loaded with sewage and manufacturing wastes the condition of the water is inferior to that at a point where it has been diluted by an influx of pure water from an unpolluted tributary.

Little or no attention has been given to the tributaries entering the main artery above the Massachusetts State line, and the highest branch concerning which we have information is Millers River.

MILLERS RIVER.

Millers River (see fig. 8) enters the Connecticut from the east at a point in Massachusetts about 10 miles south of the New Hampshire line. Its basin adjoins that of the Chicopee on the south and extends over into the State of New Hampshire on the north, covering about 395 square miles. The drainage area is hilly, especially near the river's confluence with the Connecticut, but farther back there are large areas of flat land. Lakes and ponds are plentiful, having a total area of 3,200 acres.

The flow of the river is very steady and its consequent value as a power stream is large. From Winchendon, near its headwaters, to its mouth there is a fall of 775 feet, the distance being not more than 30 miles. All of this fall is not available for development, however,

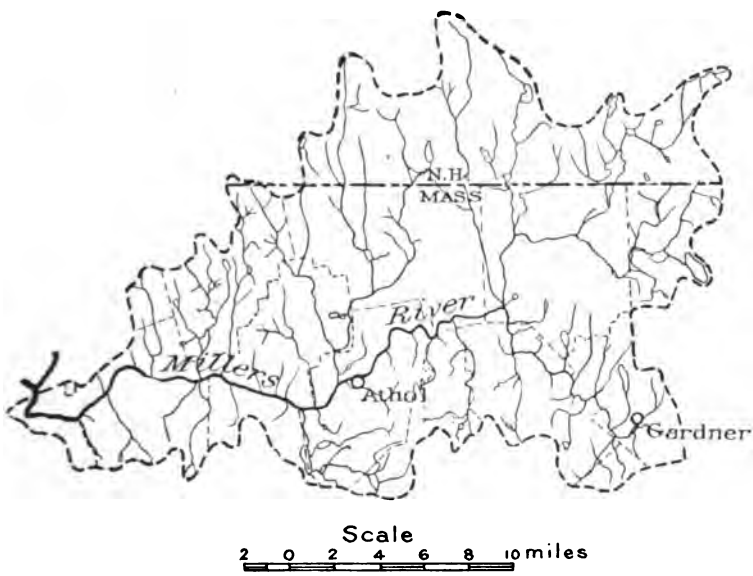

FIG. 8.—Millers River drainage basin.

as the course of the river for considerable distances partakes of the nature of a ravine; the banks are high and steep and little opportunity is afforded for the establishment of mills. The only available flow measurements are those made during October, November, and December, 1887, at the dam of the New Home Sewing Machine Company, at Orange. During this period the average monthly flow varied from 1.10 to 1.45 cubic feet per second per square mile. The population in the basin of Millers River is about 96 per square mile. This, however, does not fairly represent the conditions at the upper end of the area, for there the population is extremely dense, especially at Gardner. During the decade 1890–1900 there was a fair percentage of increase in the towns drained by this river, although it was for the most part confined to the towns of Gardner, Athol, Orange, and Win

chendon, while there was a decrease in the remaining places. Water supplies have been established at the above-named places, while sewerage systems have been laid at Orange and Gardner. These facts make it patent that Millers River receives considerable pollution, and, as the greatest population is near the headwaters, the river is unfitted for several uses throughout its whole length.

NORMAL WATER IN MILLERS RIVER.

It appears from the Massachusetts map of normal chlorine that the normal for Millers River varies from 0.8 to 1.2 parts per million, averaging about 1. Reports of the analyses of normal water are not plentiful for this drainage area, the only one appearing in the Massachusetts reports is of the well at the waterworks at Winchendon. This and several others in which the amount of chlorine does not greatly exceed the normal are reproduced in the following table:

TABLE 42.—*Analyses of normal water in Millers River drainage area.*

[Parts per million.]

Location.	Color.	Nitrogen as—				Chlorine.	Residue on evaporation.	Hardness.	Number of analyses made.
		Ammonia.		Nitrites.	Nitrates.				
		Albuminoid.	Free.						
Well in Winchendon	0.33	0.012	0.004	0.000	0.043	1.1	31.4	11	18
Orange waterworks	1.6	.112	.010	.000	.019	1.8	30.6	6	32
Athol waterworks	6.9	.342	.067	.000	.049	1.3	38.1	6	8
Gardner waterworks	.7	.161	.014	.000	.055	3.3	30.3	10	(a)

a Covering eight years.

The characteristics of the waters represented in the foregoing table are well shown. They are all acceptable for any of the ordinary uses and retain all the values of natural waters. The first and only normal water in the list is a well water. That it is a typical well water is shown by the color, which is very faint, practically absent. The low content of free and albuminoid ammonia is what might be demanded in a well water, and the evidences of its condition are further borne out by the absence of nitrites.

The Athol and Orange waters are from impounding reservoirs, and therefore are largely made up of surface drainage. The analyses show that oxidation had been rapid and that the character of the water is acceptable. The chlorine is above the normal, not very much to be sure, but sufficient to denote that the drainage area of the reservoirs has a certain population which contributes sewage to the natural drainage, and although its bad effects have long since been washed

away the traces still remain and neither water can be classed as normal.

The analysis of the Gardner water is instructive. It is apparently a water which has at some time been highly polluted, but which, through filtration, sedimentation, etc., has been reclaimed. The amount of chlorine, 3.3 parts per million (the normal for this country being 1.2) is unmistakable evidence of past pollution. In the previous pages mention has been made of waters which have been redeemed from contamination by means of artificial filters, but this is the clearest case noted in which the work has been done by natural conditions only.

Parts of the drainage basin of Millers River are thickly settled, which will account for the fact that none of the surface waters thus far analyzed are normal. The amount of chlorine found in a surface water bears a direct relation to the number of persons dwelling upon the land drained by that water. It follows, then, that while it may be impossible in a thickly settled country to secure normal water in large quantities, it is not necessarily impossible to so dispose of the wastes from the inhabitants that the resulting surface water may serve all purposes to which normal waters are applicable.

POLLUTION IN MILLERS RIVER.

The water of Millers River has been examined regularly by the Massachusetts State Board of Health at a point above Athol, where the pollution from Gardner and Winchendon may be detected, and again at a point below Orange, where the water contains the pollution from Gardner, Winchendon, Athol, and Orange. The analyses at these points are reported in Tables 43 and 44.

TABLE 43.—*Analyses of water from Millers River above Athol.*

[Parts per million.]

Date of collection.	Appearance.			Residue on evaporation.		Ammonia.				Chlorine.	Nitrogen as—		Oxygen consumed.	Hardness.
	Turbidity.	Sediment.	Color.	Total.	Loss on ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
1900.														
July 17	Very slight.	Very slight.	6.1	36.0	15.0	0.072	0.264	0.240	0.024	2.0	0.010	0.000	8.1	5
Aug. 21	Decided	Considerable.	7.8	51.0	21.0	.032	.480	.344	.136	1.2	.030	.004	10.3	11
Sept. 19	do	do	7.0	64.5	17.5	.020	.775	.268	.507	1.4	.100	.002	6.7	11
Oct. 16	Very slight.	Very slight.	8.7	64.5	24.0	.048	.300	.284	.016	1.9	.110	.000	12.5	18
Nov. 20	Slight	do	7.2	53.0	17.0	.028	.360	.204	.156	1.9	.120	.000	10.9	14
Dec. 20	Very slight.	Considerable.	5.0	37.5	15.0	.018	.318 .416	.160	.158	1.2	.100	.000	7.5	16
Average			7.0	51.1	18.2	.036	.416	.250	.166	1.6	.078	.001	9.3	12

TABLE 44.—*Analyses of water from Millers River below Orange.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
July 24	Slight	5.9	0.292	0.064	0.002	0.010	2.8	35.0	5
August 22	Very slight	7.0	.292	.046	.001	.050	2.4	43.5	6
September 21	do	5.4	.240	.060	.001	.040	2.1	43.0	6
October 24	do	9.0	.376	.064	.002	.030	2.6	55.5	11
November 20	do	9.5	.284	.056	.001	.060	2.6	45.0	11
December 24	Decided	6.0	.260	.124	.000	.130	2.1	45.0	6
Average		7.1	.291	.069	.001	.053	2.4	44.5	7

DEERFIELD RIVER.

The Deerfield is the second largest tributary of the Connecticut. It rises in southern Vermont, crosses the Massachusetts State line, and, a few miles across, turns eastward and enters the Connecticut about 7 miles below the mouth of Millers River. The river has been little developed, and for the most of its length runs wild and free. There are many good and available power privileges, the slope is rapid, and the country is conveniently traversed by railroads, yet very few industries have been established in it. The elevation of the Deerfield at Readsboro, Vt., at the mouth of the West Branch, is 1,154 feet, while 42 miles below, at its mouth, its elevation is about 126 feet. There is practically no storage upon the drainage area in Massachusetts and very little in Vermont, therefore the flow is variable. In many places where power sites are otherwise excellent the valleys are too narrow for the location of mills. The river drains 656 square miles.

The total population of the basin is about 24,400, or approximately 37 per square mile. There is no important city within the watershed. Garfield, with a population of 7,927, is the largest place, but it is at the mouth of the Deerfield, and is also drained by the Connecticut itself. Shelburne and Colerain are next in size, with 1,508 and 1,749 inhabitants, respectively. Shelburne Falls is the only manufacturing town in the drainage area, although there are powers developed at Hoosac and Readsboro. There are no sewerage systems in the basin, the country is not highly fertile, and these facts, taken together with the sparse population, indicate clearly the character of the water.

The Deerfield is, in effect, another river system which has been preserved in practically its original condition, with all its normal resources unaffected.

Few analyses are available to show the character of the water of the Deerfield. These are included in Table 45.

TABLE 45.—*Analyses of water from Deerfield River at various points.*

[Parts per million.]

Number.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	Place of collection.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.				
1	None	.....	0.095	0.024	0.000	0.130	.....	28.0	....	Above Readsboro.
2	Very slight	.....	.120	.020	.000	.020	.....	29.0	....	Monroe.
3	.....do.....	3.7	.110	.004	.000	.120	0.5	28.5	5	Florida.
4	.....do.....	.8	.085	.011	.000	.160	1.1	48.0	24	Colerain.
5	.....	.7	.054	.008	.000	.102	1.0	49.1	28	Leyden.
6	.....	3.2	.120	.008	.000	.097	1.0	36.0	17	Above Shelburne Falls.

Comment on the results set down in Table 45 seems unnecessary. The waters there represented are practically normal, the evidence of sewage pollution being very faint and the polluting substances having been practically all reduced to inorganic matter.

CHICOPEE RIVER.

The Chicopee is formed at Three Rivers by the union of the Quaboag, Ware, and Swift rivers. The Quaboag is the most southerly, and drains 210 square miles; the Ware drains 214 square miles, while the basin of the Swift covers 219 square miles. The total discharge averages 669 cubic feet per second.

Drainage area.—The drainage area of the Chicopee (see fig. 9) is larger than that of any other tributary of the Connecticut, comprising 706 square miles in central and southern Massachusetts, and occupying large portions of Worcester, Franklin, Hampshire, and Hampden counties. The country is fairly prosperous, and has constantly increased in population since the middle of the last century. During recent decades this increase has been confined to the cities and large villages, the rural population having decreased considerably. The country is very accessible, being traversed by excellent railroad systems, which have been of value to the power facilities of the river. It is hilly, with open valleys, the soil being principally bed gravel crossed by ledges of red sandstone, which form numerous falls in the rivers that flow through the district. The slope of the rivers throughout the whole system averages 15 feet per mile, but the maximum for certain sections is far greater than this.

Pondage.—There are in the basin many natural reservoirs, which serve to maintain comparatively steady flow in the streams. There

FIG. 9.—Chicopee River drainage basin.

is also considerable swamp land, especially along the Quaboag River, which materially assists in the maintenance of a uniform rate of flow.

TABLE 46.—*Principal ponds in basin of Chicopee River.*

Locality.	Name of pond.	Area.	Tributary to what stream.
		Acres.	
Prescott	On West Branch of Swift River.	154	West Branch of Swift River.
New Salem	Thompsons Pond	235	Middle Branch of Swift River.
Greenwich	Curtis Pond	155	Do.
Do	Luce Pond	124	Do.
Do	West Pond	94	Do.
Petersham	Reservoir (no name given)	175	Do.
Dana	Neeseponsett Pond	118	Do.

TABLE 46.—*Principal ponds in basin of Chicopee River*—Continued.

Locality.	Name of pond.	Area.	Tributary to what stream.
		Acres.	
Greenwich	Davis Pond	100	East Branch of Swift River.
Dana	Pottapang Pond	160	Do.
Phillipston	Phillipston Pond	202	Burn Shirt River (to Ware).
Do	Pond northeast of above	130	Do.
Hubbardston	Reservoir near Westminster.	90	Ware River.
Do	Moosehorn Pond	160	Do.
Do	Asuyconie Pond	238	Do.
Hardwick	Muddy Pond	202	Do.
Barre	Reservoir (no name given)	200	Do.
Rutland	Pond west of center	135	Do.
Do	Long Pond	160	Do.
Do	Demon Pond	138	Do.
New Braintree	Two ponds near center	94 75	Quaboag River.
Oakham	Browning Pond	140	Do.
West Brookfield	Wickaboag Pond	323	Do.
North Brookfield	Brooks Pond	178	Do.
Do	Furnace Pond	305	Do.
Brookfield	Podunk Pond	508	Do.
Do	South Pond	340	Do.
Spencer	Cranberry Meadow Pond	107	Do.
	Total area of 28 ponds.	5,040	

Power values.—The Tenth Census Report on Water Power contains an excellent description of the power utilized on the Chicopee. It states that the main river is an extremely valuable one, and has gained prominence by reason of the extensive cotton and other manufacturing industries established along its course. The available fall in the river has been practically all utilized. Of the three main branches the Quaboag is the most valuable for power because of its well-sustained flow, the value of the Ware and the Swift rivers following closely in the order named.

Character of water in the Chicopee Basin.—The following towns are situated partly or wholly within the Chicopee Basin: Chicopee, Ludlow, Belchertown, Palmer, Monson, Wales, Brimfield, Warren, Brookfield, West Brookfield, North Brookfield, Spencer, Paxton, New Braintree, Ware, Enfield, Hardwick, Oakham, Greenwich, Prescott,

Pelham, Shutesbury, Dana, Barre, New Salem, Wendell, Petersham, Phillipston, Templeton, Hubbardston, Rutland, Wilbraham, and Springfield.

The population in the drainage area is about 90,000, or 127 per square mile.

WARE RIVER.

The watershed of Ware River adjoins that of the Nashua. It has an elevation in the towns of Oakham and Barre of about 645 feet above high tide. The population is small and the pollution is therefore not objectionable, and from a sanitary point of view the stream is an excellent source of water supply. The area has been considered a favorable one by the Metropolitan Water Board of Massachusetts as a part of the natural gathering ground for the future supply of Boston and the vicinity. It forms a link in the chain of gathering grounds in central Massachusetts, which will at some day in the future, when the demands require it, be connected with the Nashua and the waters carried through the long aqueducts to the distribution stations in the vicinity of Boston.

Analyses have been made periodically by the Massachusetts State Board of Health of the water in Ware River at Coldbrook station, in the town of Barre. The average results for each year are included in Table 47.

TABLE 47.—*Analyses of water from Ware River at Coldbrook station at Barre.*

[Parts per million.]

Year.	Color.	Nitrogen as—				Chlorine.	Total r...	Hardness.	Number of analyses made.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.				
1894	7.4	0.178	0.005	0.000	0.023	1.4	35.5	8	12
1895	7.8	.219	.014	.000	.051	1.7	39.6	9	12
1896	7.2	.198	.003	.000	.038	1.1	33.6	8	6
1897	8.3	.193	.010	.000	.032	1.4	36.0	7	12
1898	7.6	.196	.011	.000	.027	1.4	35.1	7	12
1899	5.0	.184	.010	.000	.032	1.4	33.8	4	12
1900	6.2	.227	.025	.000	.014	1.4	36.6	5	7

The color of the water is fairly high, due, no doubt, to a considerable extent of swamp land. The amount and condition of the organic matter is not particularly suggestive, save that the free and albuminoid ammonia in 1900 is higher than in previous years, showing additional organic pollution, the source of which is not apparent. The normal chlorine for this region is from 1.1 to 1.2 parts per million, so

that the average of 1.4 parts in the table above set forth shows a slight sewage contamination.

In the basin of Upper Ware River is Musquapog Lake, the source of the water supply of Rutland. The following analyses were made of the water from this lake in the year 1900:

TABLE 48.—*Analyses of water from Musquapog Lake.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
Jan. 31	Very slight	0.2	0.118	0.098	0.001	0.010	1.6	17.5	5
Aug. 14	do	.1	.188	.010	.000	.000	1.4	17.0	2
Sept. 26	do	.2	.130	.044	.000	.020	1.4	21.0	3
Dec. 20	do	.2	.218	.070	.001	.030	2.8	29.0	5

The water supply of Barre is collected in a reservoir within the town, the water flowing from several springs in the vicinity and from the surface of the ground for a considerable area above. Analyses of this water, made in 1898, are reported as follows:

TABLE 49.—*Analyses of water from the reservoir of the Barre Water Company.*

[Parts per million.]

Date.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1898.									
Jan. 11	Decided	1.5	0.096	0.002	0.000	0.000	1.4	25.0	10
Apr. 12	do	1.1	.272	.018	.002	.002	1.5	19.0	8
July 5	Slight	1.1	.330	.042	.001	.001	1.3	25.0	5
Oct. 5	do	1.0	.536	.156	.000	.020	1.4	25.0	8
Average		1.2	.308	.054	.001	.032	1.4	23.5	8

Ware River, after flowing by the town of Barre, which has a population of over 8,000, plainly shows the effects of pollution. A large number of the houses and some of the factories of Ware empty their wastes directly into the river. Analyses of samples of water taken from the river below the town, made by the State Board of Health, in the year 1900, are given in table 50. When these are compared with those made of the water collected at Cold Brook Station the change is clearly illustrated.

TABLE 50.—*Analyses of water from the Ware River below Ware.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
July 17	Slight	4.1	0.312	0.060	0.008	0.000	2.1	46.5	10
August 23	Decided	3.7	.324	.032	.002	.040	2.2	45.0	8
September 20	do	3.4	.404	.076	.003	.020	3.3	52.0	11
October 16	Very slight	7.3	.288	.052	.002	.040	2.4	54.0	11
November 19	Decided	7.0	.275	.110	.001	.050	2.5	49.0	14
December 19	do	5.0	.288	.132	.002	.120	2.5	51.0	11
Average		5.1	.315	.077	.003	.045	2.5	49.6	11

Not far below the point where these samples were collected Ware River joins the Swift and the Quaboag. The analyses in table 49 therefore represent the character of the water contributed by the Ware River to the Chicopee system.

SWIFT RIVER.

Swift River is the westernmost of the three main branches of the Chicopee. Below the town of Enfield it has an elevation of 376 feet above tide. It drains an area of 185.7 square miles, which has a population of 128 per square mile. This area, like that of the Ware, has been considerd as a source of water supply by the Metropolitan Water Board. The water is of excellent quality and has little color. The following analyses have been made by the State Board of Health of Massachusets.

TABLE 51.—*Analyses of water from Swift River at designated points.*

EAST BRANCH IN GREENWICH.

[Parts per million.]

Date.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	Number of samples analyzed.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.				
1894	4.7	0.146	0.011	0.000	0.015	1.5	31.0	8	2
MIDDLE BRANCH IN GREENWICH.									
1894	3.8	0.115	0.012	0.000	0.000	1.3	31.5	9	2
BARRETTS JUNCTION.									
1900	3.2	0.167	0.012	0.000	0.040	1.6	33.3	10	3
TOWN OF ENFIELD.									
1898	0.4	0.030	0.000	0.000	0.058	1.1	25.8	7	6

QUABOAG RIVER.

The Quaboag is the southernmost of the three main branches of the Chicopee. It drains the whole area of the towns of Monson, Brimfield, New Braintree, Oakham, Spencer, and Paxton. The population per square mile is 125, which is considerably larger than in the Ware and Swift basins. The character of the unpolluted water in the drainage area of the Quaboag is well shown in the following series of analyses:

TABLE 52.—*Analyses of unpolluted water in Quaboag Basin.*

[Parts per million.]

Place of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
Reservoir, Monson	1.1	0.355	0.030	0.004	0.105	1.7	34.5	....
Shaw Pond, Spencer	.3	.136	.007	.....	.059	1.4	26.9	....
Dug well, Monson	.1	.011	.002	.000	.095	1.2	33.3	10
Do	.0	.006	.001	.000	.078	1.3	32.2	7
Spring, North Brookfield	.0	.008	.010	.000	.245	1.4	37.0	9
Doane Pond, North Brookfield	5.3	.308	.145	.002	.050	1.2	31.5	4
Shaw Pond, Spencer	.3	.148	.018	.000	.090	1.6	22.2	5

The settlements along the Quaboag which contribute a considerable amount of matter to the river above the town of Palmer are Spencer, Brookfield, North Brookfield, Warren, and Monson. After the water has passed all these points it is in the condition indicated in the following table:

TABLE 53.—*Analyses of water from Quaboag River above Palmer.*

[Parts per million.]

Date of collection.	Turbidity.	Color	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
July 17	Very slight	4.4	0.196	0.040	0.001	0.010	1.9	41.0	11
August 21	Slight	5.1	.236	.032	.001	.010	2.5	47.0	10
September 19	Very slight	3.5	.208	.028	.001	.030	2.8	42.5	13
October 29	Slight	4.4	.248	.048	.002	.040	3.1	45.0	14
November 20	do	4.3	.216	.036	.000	.110	2.9	44.5	17
December 18	do	4.5	.198	.010	.003	.100	2.5	42.5	11
Average		4.4	.217	.032	.001	.050	2.6	37.7	13

After receiving considerable sewage from Palmer, the river below is not apparently in a worse condition from the standpoint of organic content than it was above that town. This fact is shown by the following analyses:

TABLE 54.—*Analyses of the water of the Quaboag River below Palmer.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
July 17	Very slight	4.1	0.180	0.040	0.001	0.030	1.8	41.0	13
August 21	Slight	5.0	.246	.044	.001	.050	2.4	51.5	8
September 19	Very slight	3.1	.198	.008	.001	.050	3.0	44.0	13
October 29	Slight	4.0	.248	.048	.002	.040	3.1	47.0	10
November 20	Decided	3.7	.216	.048	.000	.140	2.9	44.5	16
December 18	Slight	4.1	.190	.008	.003	.120	2.5	43.5	11
Average		4.0	.213	.033	.001	.072	2.6	45.2	12

A comparison of the two tables shown above illustrates in a fairly clear way a point made at the beginning of this discussion, which is, that analysis of water is not always effectual in showing its condition from the standpoint of general healthfulness. It is plain that the water of Quaboag River can not be as safe for public use after it has passed the town of Palmer as it was above this point. The amount of pollution from Palmer is rather extensive, but it is not apparent in the analysis of the water. The reason for this is probably that the amount of pollution is not sufficient to appreciably change the quantity of organic matter contained in so large a flow as that of the Quaboag, yet it is undoubtedly true that if the germs of any water-borne disease, such as typhoid fever, were brought into the river from Palmer, the use of the water below Palmer would be extremely dangerous, even though the analysis would seem to show that, from the standpoint of organic content, the river had not changed.

From the confluence of the Swift, Ware, and Quaboag rivers the Chicopee runs almost due west, past the municipalities of Ludlow, Wilbraham, Chicopee, and Springfield. The first village below Three Rivers is Ludlow, from which there is considerable sewage emptying into the Chicopee. The average of six analyses of the water below Ludlow made in the year 1900 is reported as follows:

TABLE 55.—*Analyses of water from the Chicopee River below Ludlow.*

[Parts per million.]

Year.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900	3.8	0.240	0.042	0.012	0.098	2.8	46.0	12

After receiving sewage from Indian Orchard, Chicopee Falls, and a part of Chicopee the river enters the Connecticut. No recent analyses of the water of the river at a point below that are available.

WESTFIELD RIVER.

Drainage basin.—Westfield River is a branch of the Connecticut which enters the latter from the west at a point opposite Springfield, Mass. (See fig. 10.) It has a drainage area of about 515 square miles, all of which is situated within the State of Massachusetts. Above a point 16 miles from the mouth of the river the country is extremely hilly, and in the upper districts it is even mountainous. The maximum fall from source to mouth is, where measured via the West Branch, about 1,162 feet, or an average of 32.5 feet per mile. In the

upper part of the river, however, the fall averages usually 70 feet per mile.

The rainfall on the watershed finds its way over the steep slopes rapidly and the flow of the river fluctuates in consequence. This flood flow is not steadied by any considerable storage within the basin, for there are few natural ponds or lakes, and little or nothing has

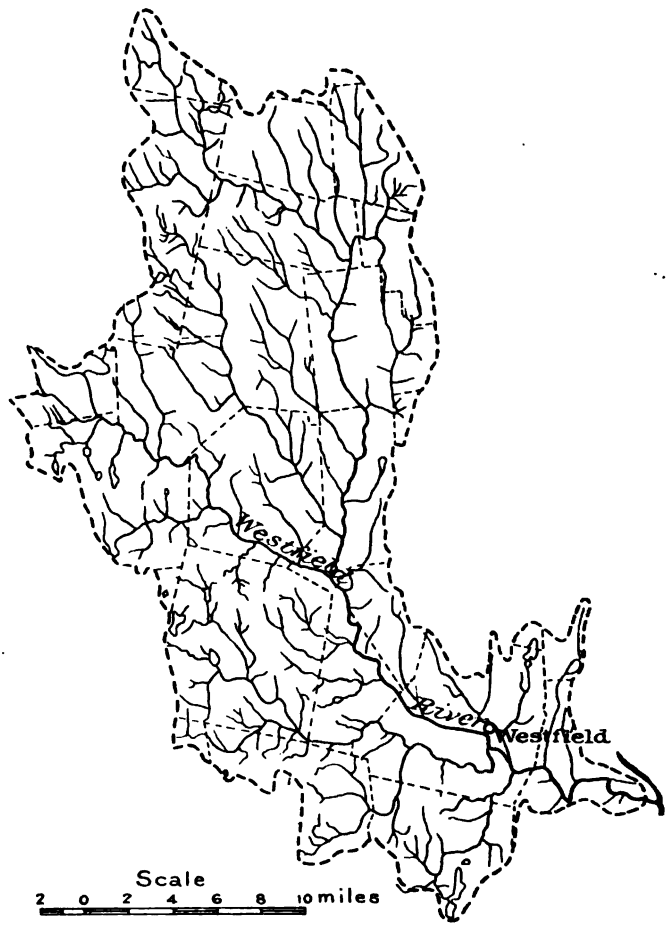

FIG. 10.—Westfield River drainage basin.

been done to impound the waters. Gen. Theodore G. Ellis, Chief of Engineers, U. S. Army, has given the average flow of the river as 500 cubic feet per second, but this is believed by Professor Porter to be too large.

Population.—The development of the drainage area of the Westfield has been slow and the growth of population slower. In a great majority of the towns there has been a decrease in the number of

inhabitants within the decade 1890–1900. A large part of the basin has no railroad facilities whatever, and there has been no need of any. In short, the country has not shared the industrial and commercial advancement which has been made by the greater part of the surrounding sections. In the lower parts of the area, notably in Westfield, there has been an increase in population amounting to 25 per cent in the last decade. Exclusive of this town and West Springfield, the most populous part of which drains into the Connecticut, the drainage area has a population of about 23 per square mile.

Character of water.—On account of the small population the character of the water is excellent, and the river above the town of Westfield may be considered practically unpolluted. The following expressive statement is found in the report of the State Board of Health of Massachusetts for 1890:

> Analyses of the water of the Westfield River have not been made regularly, because it was polluted so little during the time covered by these investigations (1887–1889) that it seemed unnecessary.

As above noted, conditions in the river have not changed, except in the lower end; therefore the passage quoted applies at the present time. The construction of a sewerage system at Westfield and the location of its outlet in the river has made it necessary to examine the waters above and below the outlet in order to show the effect upon the river. In the investigation of water supplies for different towns in the district, several analyses of water in the drainage basin were made.

TABLE 56.—*Analyses of normal water of the Westfield River system.*

[Parts per million.]

Point of taking sample.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	Number of samples analyzed.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.				
Chester	None	0.9	0.068	0.004	0.001	0.120	1.0	32.5	11	1
Huntington (Middle Branch).	do	.9	.063	.004	.000	.043	.9	32.1	15	14
Huntington (East Branch)		1.4	.087	.005	.000	.053	1.0	33.2	14	14
Russell	Very slight.	1.2	.078	.010	.000	.070	.7	32	1	1
Granville		1.3	.071	.013	.000	.027	1.2	26.7	4	14

The above analyses represent the characteristics of water, which may fairly be called normal, obtained from different parts of the drainage area. It will be seen that there is very little difference in the color of the various samples and that the residue and the albuminoid ammonia are remarkably uniform. The Granville sample shows higher free ammonia and chlorine than the preceding ones, which for the moment looks threatening, but it will be seen that the actual departure from the normal is wholly within the limits of error, and if there is any pollution in the Granville sample it is not sufficient to produce significant changes, so that the water from nearly the whole Westfield area is of practically normal character. The basin remains in a condition in which may be realized all the resources which its streams can provide. The public demand for drinking water may be met at almost any point, and there is no blemish on the ice fields. The manufacturer may use the water with impunity, for it is not changed sufficiently to injure his products. That this district, lying between the metropolitan area of New York and the prosperous country of central Massachusetts, should remain throughout its greater part in normal condition is worthy of remark.

We will now trace the changes that take place in the water of Westfield River after it passes the town of Westfield, with its population of 12,310.

TABLE 57.—*Analyses of water from Westfield River above and below Westfield.*

[Parts per million.]

Point of taking sample.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	Number of samples examined.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.				
Above Westfield	2.2	0.135	0.013	0.000	0.035	1.3	42.6	19	15
Below Westfield	2.0	.296	.128	.004	.069	2.3	49.9	23	11

The analyses in the table above are of peculiar interest, as they show the effect of a single sewerage system on a pure stream. From what has gone before it will be remembered that Westfield River receives practically no significant pollution until it reaches the city of Westfield, but in passing the city it is changed from a normal river to a polluted one. Let us consider the significance of the determinations in Table 57. The average of the samples taken below the city shows a great increase in the amount of polluting material. Free ammonia, nitrites, and chlorine, the special indicators of the presence of sewage pollution, are all present in increased quantities, while the

amounts of nitrates and albuminoid ammonia assume a proper relation to the whole.

HOCKANUM RIVER.

Drainage area.—On the boundary between the towns of Tolland and Ellington, Conn., there is a lake, the level of which has been so raised by a stone embankment 35 feet high that it has an expanse of 680 acres. Its drainage area is 15.4 square miles, but in addition to the surface water which accumulates from this territory, it is largely fed by hidden springs. This lake, called Shenipsit, is the source of Hockanum River, which flows thence in a southwesterly course, emptying into Connecticut River opposite Hartford. The Hockanum is principally important by reason of the power developed along its course, for although it is less than 20 miles long it furnishes 3,957 horsepower.

Flow.—According to the measurements of General Ellis, Chief of Engineers of the U. S. Army, the flow of the river averaged 132 cubic feet per second, its maximum flow being 6,167 second-feet. The flow is peculiar by reason of the fact that about 2,000,000 cubic feet a day are allowed to run from Shenipsit Lake during working hours while no water is permitted to flow at night or on holidays.

There are several factories on the banks of the river, most of them works for the manufacture of textile fabrics and paper. Just below Shenipsit is Rockville, where 1,400 horsepower are developed.

Character of water.—Shenipsit Lake drains an area which is sparsely settled, and its water is therefore practically normal and of excellent quality. It is used as a supply for the city of Rockville and has been analyzed by the State Board of Health of Connecticut.

TABLE 58.—*Analyses of water of Shenipsit Lake.*

[Parts per million.]

Date of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	Samples averaged.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.				
1890–91	0.1	0.194	0.027	0.001	0.05	1.66	31.3	7	11
1900	.3	.107	.021	.000	.08	1.42	31.2	5	12

Taylor's reservoir, on the south branch of the Hockanum, is another body of normal water. It is used as a source of supply for South Manchester, Conn. Analyses made by the Connecticut State Board of Health in the year 1900 are reported as follows:

TABLE 59.—*Analyses of water from Taylor's reservoir, Manchester, Conn.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
Jan. 24	Very slight	0.4	0.130	0.028	0.001	0.10	1.7	34.5	3
Mar. 15	Clear	.1	.102	.044	.001	.05	1.5	32.0	5
May 10	do	.2	.110	.038	.002	.05	1.5	34.0	5
July 3	do	.1	.068	.022	.001	.02	1.7	35.0	3
Sept. 13	do	.1	.108	.018	.000	.03	1.6	36.5	4
Nov. 7	do	.1	.112	.112	.000	.08	2.1	37.5	3
Average		.2	.105	.025	.001	.05	1.68	34.9	4

Pollution.—The Board of Health of the State of Connecticut is investigating the character of the water in Hockanum River, samples being collected at three available points, viz, Windermere, North Manchester, and Burnside.

This work was done during the years 1895, 1896, and 1900, the samples being collected monthly, from May to October in each year. They indicate extensive pollution of this stream, but since its principal resource is water power, the damage done is not significant. The character of the water will doubtless be better in the future, by reason of the installation of a sewage purification plant in the village of South Manchester.

TABLE 60.—*Analyses of water from Hockanum River at Windermere, North Manchester, and Burnside.*

[Parts per million.]

WINDERMERE.

Year.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1895	0.5	1.470	0.071	0.017	0.160	4.85	138.9	13
1896	.5	.913	.070	.008	.180	4.49	98.6	....
1900	.4	.910	.073	.010	.250	3.38	71.9	....

TABLE 60.—*Analyses of water from Hockanum River, etc.*—Continued.

NORTH MANCHESTER.

Year.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1895	0.5	1.096	0.124	0.008	0.110	3.87	82.1	15
1896	.5	.762	.063	.009	.160	4.45	78.3	....
1900	.3	.752	.167	.022	.240	3.95	75.4	....

BURNSIDE.

1895	0.4	0.802	0.172	0.025	0.100	6.03	98.6	37
1896	.4	1.156	.194	.023	.140	5.61	81.4	....
1900	.4	.722	.183	.025	.160	4.65	80.7	....

PARK RIVER.

Park River is a small stream entering the Connecticut from the west. In its drainage area are the cities of New Britain and a part of Hartford. The flow is small, and, as there is a large amount of sewage brought into the river, it is probably the foulest stream in the State of Connecticut. The report of the State Board of Health made in 1895 contains the following comments:

The result of the analyses at New Britain indicate that at times during the summer the water of the stream contained as much as four-fifths of its volume of sewage. Between New Britain and section No. 2, at Newington Junction, there is practically no sewage addition. From the respective areas of the watersheds the volume of the stream at Newington should be about five times what it is at New Britain, but that the dilution must be less than this is at once apparent when it is considered that the greater part of the flow at station No. 1 is sewage and comes from other watersheds, from which the water supply is drawn. A better means of measuring dilution is by the comparison of the amounts of chlorine at the two stations, for this constituent is not removed from the stream after once having been introduced, either by precipitation or by the acts of living organisms. Since the normal chlorine of the region is about 2, there would be two parts of chlorine per million in the water of dilution added between New Britain and Newington, and, since the average amount of chlorine at the two stations is 33.1 and 15.1, respectively, it is easy to calculate that the dilution at Newington Junction is 2.4.

The average amount of nitrogen of free ammonia at New Britain was 3.04. A dilution to the extent indicated above would reduce the nitrogen of free ammonia at Newington Junction to 1.25, but the amount actually found was 2.35, a very considerable increase. This, of course, was due to putrefactive change occurring during the flow of 3¼ miles. That the changes occurring during this course were putrefactive and not oxidizing in character is shown, not alone by the increase of free

ammonia, but also by the figures for nitrites and nitrates, which show no increase, but, on the contrary, a slight relative diminution.

A similar calculation for the nitrogen of organic matter in suspension shows that there was a decrease of about 30 per cent, due, doubtless, chiefly to sedimentation. The decrease of nitrogen of organic matter in solution was somewhat more than the increase of nitrogen of free ammonia. In flowing through the course of 3¼ miles, therefore, there was some purification by sedimentation, but apparently none by oxidation, and very little by precipitation and other means. The improvement in the stream at the lower point is consequently due almost wholly to dilution with clean water from the watershed between the two stations.

Below Newington Junction there is a large increase in the flow, the relative watersheds being as 1 to 5.6. There is little direct contamination until the sewers of Hartford are reached. There are several of these in the last mile above station No. 3 in Hartford. The contamination effected by their discharge is so great that, although there is a dilution of nearly sixfold, the water in the stream at this point is about in the same condition as at Newington Junction; indeed, in respect to the organic matter the contamination is greater in Hartford.

Analyses of the water of this river were made by the Connecticut State Board of Health in the years 1895, 1897, and 1899 at New Britain, Newington, and Hartford, and the average of the results for each year are set forth in Table 61.

TABLE 61.—*Analyses of water from Pipers Brook and Park River.*

[Parts per million.]

Date of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Samples analyzed.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
NEW BRITAIN.								
1895	0.5	6.71	3.04	0.396	1.15	33.0	290.9	6
1897	.4	7.08	3.41	.217	1.24	26.2	271.6	6
NEWINGTON.								
1895	0.7	1.57	2.33	0.064	0.37	15.1	160.8	6
1897	.6	2.64	2.07	.064	.28	13.2	150.0	6
1899	.8	2.52	4.42	.024	.09	16.9	155.6	6
HARTFORD.								
1895	0.6	3.71	2.27	0.035	0.19	13.1	151.9	6
1897	.5	5.21	2.17	.158	.23	17.0	172.2	6
1899	.4	2.22	1.22	.208	.20	9.2	138.3	6

The pollution of Pipers Brook by the city of New Britain led to a lawsuit against the city, the final decision in which was rendered by the supreme court of errors of the first judicial district of the State of Connecticut, during the May term, at Hartford, in 1897. The suit was brought for injunction and damages before the superior court in Hartford County by Patrick Nolan, the jury giving verdict and judgment for plaintiff in $2,000 damages. The plaintiff owned a farm near Newington on Pipers Brook below the city of New Britain, upon which were dwelling houses and other buildings. The complainant stated that from October 1, 1887, to the date of complaint, the city had dumped acid, sewage, and other deleterious matter into the river and deprived him of the use of water for stock and for domestic purposes, and he had been put to a large expense thereby, his lands being injured for pasturage, his milk business having been injuriously affected, and the ice crop upon the stream having been made valueless.

The following extracts are taken from the opinion rendered by the court, the same having been handed down by Chief Justice Andrews (69 Conn., 668):

The use of Piper's Brook which the complainant charges that the defendant has made, unless there is a lawful warrant therefor, causes a public nuisance. Anything not warranted by law, which annoys or disturbs one in the use of his property, rendering its ordinary use or occupation physically uncomfortable to him, is a nuisance. (Baltimore and Ohio Railroad *v.* Fifth Baptist Church, 108 U. S., 317.) * * * The test is not the number of persons annoyed, but the possibility of annoyance to the public by the invasion of its rights. * * * (Westcott *v.* Middleton, 43 N. J. Eq., 478.) * * * That it would be a public nuisance to render the water of a stream so impure that it could not be used for domestic purposes, or for the watering of cattle, and so that it gave off noxious and unhealthy odors, is hardly open to question (Chapman *v.* Rochester, 110 N. Y., 273), for the reason that these causes would injuriously affect every riparian owner along the whole length of the stream and every person who lived near it. If a municipal corporation, in the absence of a legal right so to do, causes sewage to pollute a watercourse, to the use of which a lower owner, through whose premises the watercourse flows, is entitled, it is guilty of a nuisance for which damages may be recovered. * * * * * * The second defense depends on the act of the legislature of 1872, mentioned in the statement of the case.

* * * The said act authorizes and points out the steps to be taken in order to complete within said city a valuable public improvement, to be paid for by that species of taxation known as the assessment of damages and benefits. It empowers the common council, "whenever in their opinion the public health or sewerage shall require such action, to take, occupy, and appropriate, in such manner as they shall, from time to time, deem expedient, any stream or part of a stream, natural or artificial, running in or through said city, and to straighten, deepen, or lower the same, or lower or remove any or all walls, dams, or other obstructions to the free and healthy flow of such stream or part of a stream, or to enlarge or cause to be enlarged or lowered, any or all culverts which at any season of the year cause the accumulation of stagnant water or interrupt in any manner the free and healthy flow of any part of such stream." This is all of the act which grants power to the defendant to interfere with Piper's Brook. * * *

If it had been the intent of the legislature, by the act of 1872, to authorize the

common council of the city of New Britain to take or to affect any lands outside of the city limits, it is certain that there would have been in the act some provision for the ascertainment of damages to be paid to the landowner. The right of the plaintiff to have the water of Piper's Brook flow through his land as it has been accustomed to flow [i. e., pure and uncontaminated] "is not an easement or appurtenance, but it is inseparably annexed to the soil." (Wadsworth *v.* Tillotson, 15 Conn., 366, 373.) To deprive the plaintiff of that part of his soil for the purposes named in that act would be the taking of private property for public use, and the plaintiff would be entitled to have just compensation.

The procedure of the trial court was sustained and the award affirmed.

FARMINGTON RIVER.

Farmington River is an important stream which rises in Berkshire County, Mass., and, after a peculiar and erratic course, enters Connecticut River from the west about 5 miles above the city of Hartford. It is a notable power stream, having a fall of about 1,200 feet, a mean discharge at the mouth of the river of about 944 cubic feet per second, and a maximum discharge of nearly 25,000.

The surface of the Farmington River Basin is hilly, the uplands are well wooded, and the valleys extensively cleared for farming purposes. There are many ponds in the basin, and these, with the surface waters, maintain a fairly steady flow during the dry seasons. Indeed, it has been claimed that the development of water storage on this river has practically reached its height.

No examinations of water of the Farmington River are available. Although there are a number of thriving manufacturing villages along its course, there are no important towns in the basin; therefore pollution can not be sufficiently extensive to greatly damage the river.

CONNECTICUT RIVER.

Analyses of the water of Connecticut River at Northfield Farms, in the northern part of Massachusetts, just below the State line, show that the pollution which enters from the States of Vermont and New Hampshire has very little effect on the apparent composition of the water. Indeed, such is the dilution of the sewage poured into the river north of the Massachusetts line that the chlorine in the water at Northfield is nearly normal. In the Connecticut Valley in New Hampshire and Vermont there are only a few important towns, and these are probably not completely sewered, if at all. Brattleboro and Bellows Falls in Vermont, with populations of 5,297 and 4,377, respectively, are the only places in that State from which there is likely to arise any appreciable pollution. In New Hampshire, the city of Keene drains into the Connecticut by way of the Ashuelot, and the town of Claremont is situated directly upon the river. These places have populations of 9,165 and 6,498, respectively.

TABLE 62.—*Analyses of water from Connecticut River at Northfield Farms.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
July 18	Slight	2.8	0.156	0.012	0.001	0.000	0.6	60.5	30
August 20	Very slight	3.0	.142	.006	.003	.040	.8	60.5	33
September 17	do	2.4	.114	.006	.000	.010	1.1	71.0	38
October 15	do	8.3	.270	.045	.000	.050	.8	62.5	22
November 19	Slight	6.8	.270	.044	.001	.050	1.0	57.5	21
December 17	Very slight	2.4	.148	.024	.006	.190	1.1	60.5	30
Average		4.3	.183	.023	.002	.057	.9	62.1	29

The available analyses of the river's water next below Northfield Farms were made at Turners Falls, in the town of Montague, from 1887 to 1889. Although, under ordinary circumstances, a series of analyses made at such an early date would not be applicable to the present conditions, the changes in the population above this point have not been sufficient to materially alter the condition of the river. The average of 21 analyses is set forth in Table 63.

TABLE 63.—*Average of twenty-one analyses of water from Connecticut River at Turners Falls.*

[Parts per million.]

Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.		
Slight	3.0	0.140	0.025	0.003	0.123	1.0	63.8

The report of the Massachusetts State Board of Health for 1899 gives a significant analysis of the water of the Connecticut River opposite Northampton as follows:

TABLE 64.—*Analysis of water from Connecticut River at Northampton.*

[Parts per million.]

Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
Very slight	3.0	0.232	0.018	0.001	0.030	0.9	57.5	26

Continuing downstream we find that the next available analyses are those made by the State Board of Health of water taken from Connecticut River at a point below Springfield. Here are the first prominent indications of pollution shown by analytical methods. Above this point there are Chicopee, Westfield, and Millers rivers, which are, as has been already stated, in a polluted condition. On the main river there are the cities of Northampton, Springfield, and Holyoke, as well as smaller towns, all of which contribute a large measure of pollution. It is not surprising then, that by the time the river reaches this point below Springfield it should betray by chemical analyses the abuse which it has suffered.

TABLE 65.—*Analysis of water from Connecticut River below Springfield.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
July 17	Very slight	2.5	0.184	0.112	0.002	0.010	1.7	61.0	34
August 13	Slight	2.4	.148	.112	.002	.020	1.6	61.5	34
September 18	Decided	2.9	.280	.156	.004	.040	2.9	78.5	36
October 18	Very slight	7.1	.268	.064	.002	.020	1.7	66.0	25
November 21	Decided	7.2	.368	.048	.002	.080	2.0	65.0	27
December 29	Slight	2.6	.152	.006	.001	.090	1.8	49.0	25
Average		4.1	.233	.083	.002	.043	1.9	63.5	30

Crossing over into the State of Connecticut, the river receives other and extensive pollution. The Farmington, Hockanum, Salmon, and other tributaries have already been discussed. On the main river are Hartford and Middletown, as well as numerous other smaller centers, which materially increase the amount of pollution. In the years 1890, 1893, 1894, and 1899, the State Board of Health of Connecticut made examinations of the water of the river at three points, viz: Warehouse Point, Rocky Hill, and Goodspeed Landing. Analyses made at these points are well adapted to show the effects of the contribution by various towns of new contamination to the already polluted river.

TABLE 66.—*Analyses of water from Connecticut River at Warehouse Point, Rocky Hill, and Goodspeed Landing.*

[Parts per million.]

Year.	Color.	Nitrogen as-				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
WAREHOUSE POINT.								
1890–91	3	0.126	0.034	0.002	0.12	1.23	44.2	23
1893	3	.116	.086	"much"	.20	1.85	66.5	....
1894	3	.192	.064	.005	.06	2.58	76.5	44
1899	2	.130	.048	.002	.15	2.70	77.5	30
ROCKY HILL.								
1890–91	3	0.135	0.033	0.002	0.11	1.28	44.6	25
1893	3	.112	.054	.010	.10	1.75	66.5	....
1894	3	.156	.102	.006	.30	3.50	73.5	48
1899	3	.164	.068	.008	.18	2.70	73.5	32
GOODSPEED LANDING.								
1890–91	3	0.130	0.036	0.001	0.13	1.36	45.0	25
1893	3	.110	.044	.005	.08	1.81	65.5	....
1894	2	.182	.064	.004	.08	3.04	73.0	44
1899	3	.244	.066	.008	.20	3.20	73.0	32

There is little to add concerning the Connecticut River and its relations to the various interests which have claims upon it. There is no reason why this stream could not be kept in a condition that would be acceptable to all concerned. Under the present conditions, however, much of its value is lost. The river comes down to the Massachusetts line practically uninjured, but in its course through Massachusetts it is robbed of its values as a source of water supply and of ice. Under the present policy of the State authorities the condition of the river is not likely to grow worse, but, on the contrary, will no doubt be improved, so that we can look forward with confidence to the removal of the dangerous wastes which are now poured into the Connecticut system in Massachusetts. In Connecticut the river has great values as a source of power, as a means of navigation, and as a park nucleus, but the remainder of its normal values have been destroyed.

HOUSATONIC RIVER.

NATURAL RESOURCES.

Course.—The Housatonic is an important stream flowing through the extreme southwestern part of New England. It has its origin in the central part of Berkshire County, Mass., being formed by the confluence of East and West branches, which unite at Pittsfield. From Pittsfield it flows southward in a somewhat tortuous course, passing into Connecticut through Litchfield County, and still farther south forming the boundary between New Haven and Fairfield counties, finally emptying into Long Island Sound near Bridgeport. (See fig. 11.)

Drainage basin.—The area drained by Housatonic River comprises 1,933 square miles, of which 503 are in Massachusetts. The river in its winding course traverses about 125 miles. The East Branch, which has a drainage area of 70 square miles, rises not far from Pittsfield, and flows by an extremely circuitous route through the manufacturing settlements of Hinsdale and Dalton, finally joining West Branch south of Pittsfield. The West Branch is formed by the overflow of Onota and Pontoosuc lakes, in Pittsfield, and flows in a southerly direction, draining an area of 59 square miles. One of the principal branches of West Branch is Southwest Branch, which rises in Richmond Lake and joins West Branch a short distance above its confluence with East Branch.

Fall.—The fall of the river between Pittsfield and Long Island Sound amounts to about 1,000 feet. It is distributed along gravelly shoals, with intervening stretches of quiet water. There are falls at New Milford, Bulls Bridge, and Falls Village.

TABLE 67.—*Table showing fall in Housatonic River.*

Locality.	Distance above mouth.	Elevation above mouth.	Fall between points.	Distance between points.	Average fall per mile between points.
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*
Pittsfield, Mass	123	983			
Ashley Falls, Mass	81½	705	361	50.5	7.15
Falls Village, Conn	72½	622			
1.8 miles above Cornwall Bridge	64	457	165	8.5	19.41
Mouth of Shepaug River	29½	105	352	43.5	10.20
Birmingham	11		105	18.5	5.68

The drainage area is hilly and even mountainous, the uplands are fairly well wooded, and the valleys are wide, with alluvial meadows. The falls in the river are over ledges of limestone and granite, and fairly good building marble is quarried. A small amount of iron ore is mined. There is also easily available a pure quartz sand which has become famous in the glass industry.

The country is prosperous, and the power facilities have attracted a skilled class of artisans. The principal industries are the manufacture of paper and woolen goods. The railroad facilities are very good.

Flow.—The flow of the river is fairly steady, because of the large storage area, which is partly natural and partly of artificial development. It is probable that the reservoir capacity has been developed to nearly its full extent. The approximate area of 35 ponds and reservoirs in the basin is 9,304 acres.

The principal ponds are Pontoosic Lake, Lanesboro, Mass., 313 acres; Onota Lake, Litchfield, Mass., 555 acres; Ashmere reservoir, Hinsdale, Mass., 310 acres; Washinee Lake, Salisbury, Conn., 400 acres; Washining Lake, Salisbury, Conn., 650 acres; Wononscopomus Lake, Salisbury, Conn., 355 acres; Quassapaug Pond, Middlebury, Conn., 535 acres; Bantam Lake, Litchfield, Conn., 1,070 acres; North Pond, Goshen, Conn., 300 acres.

There have been no gagings of the river extending over a period

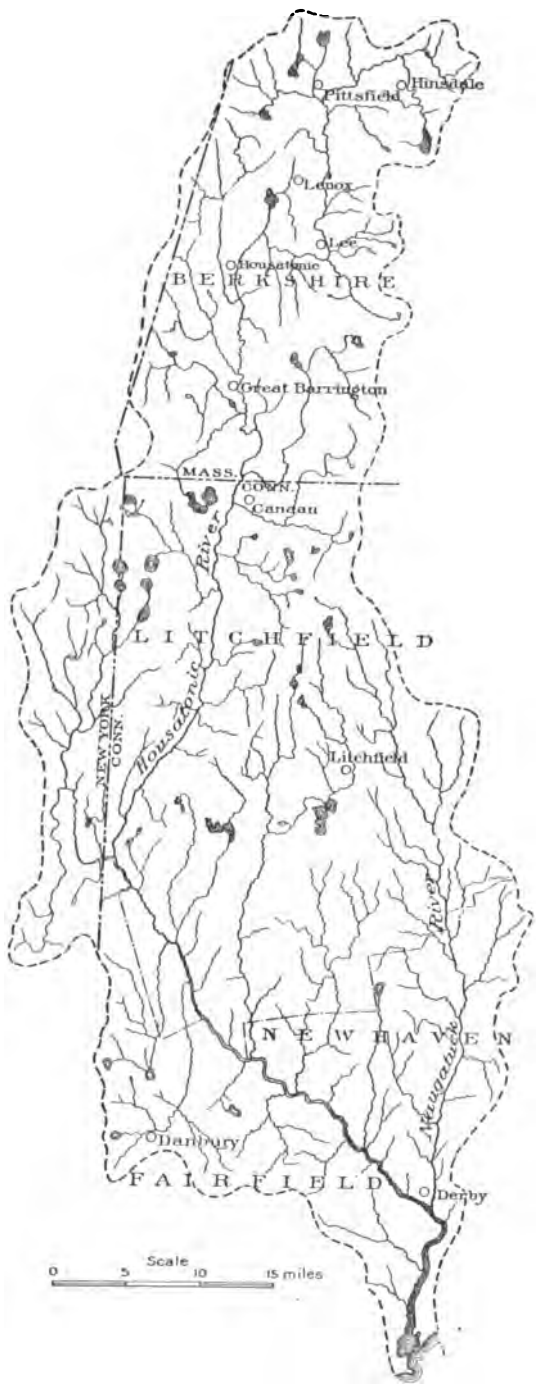

FIG. 11.—Housatonic River drainage basin.

sufficiently long to determine its flow with accuracy. In the year 1878 careful examinations were made from May to November at Kent, by the water department of New York, and the results probably show fairly well the summer flow of the river. According to these gagings the minimum flow for twenty-four hours was 260 cubic feet per second, while the average flow for the same period amounted to 460 cubic feet per second.

Water power.—After what has already been stated it is hardly necessary to say that the river may be valuable as a source of power. The total utilized horsepower on the whole system is about 18,884. In the main river the utilized horsepower is 6,434, and the remainder is distributed among the tributaries as follows: Naugatuck River, 4,909; Mad River, 1,220; Pomperaug River, 361; Shepaug River, 695; all other tributaries, 5,265.

The details of the power system are well set forth in the Tenth Census Report on Water Power, Vol. XVI.

NORMAL WATER IN THE HOUSATONIC BASIN.

The limestone formations in the Housatonic Basin make the water hard. In other respects the normal Housatonic water does not materially differ from that in the Connecticut Basin. The normal chlorine for this region varies from about 0.8 part per million at the upper end of the area to 3 parts near the mouth of the river.

The following table of analyses represents the averages of the results of various examinations of water made during the past decade.

TABLE 68.—*Analyses of various normal waters in the Housatonic drainage area.*

[Parts per million.]

Place of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
East Branch of Housatonic above Hinsdale.	Slight	2.0	0.138	0.086	0.001	0.180	0.8	54.0	----
Lake Oneota, Pittsfield	Very slight	0	.158	.000	.000	.080	.3	66.0	----
Pontoosuc Lake, Pittsfield.	do	0	.128	.006	.000	.000	.4	79.0	----
Egypt Brook, Dalton	do	2.9	.080	.002	.000	.196	.7	27.3	----
Green River, Great Barrington.	do	------	.028	.005	.000	.225	1.0	74.1	56
Hinsdale storage reservoir.	do	2.1	.202	.017	.000	.017	.7	20.7	1
Upper reservoir, Berkshire Water Co.	do	3.9	.308	.056	.000	.027	1.0	26.7	4
Millbrook reservoir, Pittsfield.	do	.1	.095	.011	.000	.057	.9	53.5	40
Lake Averic, Stockbridge.	do	.8	.181	.021	.000	.022	.8	62.0	40
Padaranium reservoir, Danbury.	do	.3	.162	.080	.003	.09	1.95	47.7	13
Kent reservoir	do	.1	.080	.008	.000	.12	1.56	64.5	30
North Canaan	do	.02	.080	.004	.001	.05	1.25	111.6	93
Farm Brook	do	.4	.105	.022	.001	.11	1.84	50.2	12

POLLUTION IN THE HOUSATONIC.

The population in the Housatonic Basin has increased rapidly during recent years, and the consequent pollution has become a matter of grave consideration.

The East Branch of the Housatonic receives pollution from the manufacturing villages of Hinsdale and Dalton, which have a population of 1,485 and 3,014, respectively. The report of the State Board of Health for 1890 gives analyses of water collected below these villages which show a considerable increase in the amount of organic matter present. A comparison of the analyses in Table 69 with the first analysis presented in Table 68 will clearly show indications of sewage pollution.

TABLE 69.—*Analyses of water from East Branch of the Housatonic above Pittsfield.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.		
1888.								
Sept. 7	Slight	2.0	0.238	0.092	0.008	0.180	1.9	112
Do	Distinct	2.0	.390	.092	.003	.200	2.0	117.5

Although these analyses were made in the year 1888, the conditions now existing in the river compare very closely to those found in the year of the analyses. The population in this part of the drainage area has not increased materially and the analyses therefore fairly represent existing conditions.

TABLE 70.—*Analyses of water from the East Branch of the Housatonic at Pittsfield.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
June 26	Slight	2.4	0.264	0.192	0.004	0.100	1.4	92.5	56
July 27	Decided	2.2	.416	.128	.006	.070	2.6	101.5	70
September 14	do	2.4	.244	.100	.009	.060	3.1	122.5	87
September 25	Very slight	2.2	.412	.168	.007	.100	3.0	126.5	91
October 23	Slight	3.0	.464	.196	.008	.120	3.9	135.5	97
November 20	Decided	4.0	.416	.060	.002	.190	2.4	98.5	63
December 18	Slight	2.1	.324	.106	.006	.310	2.3	106.5	79
Average		2.7	.369	.136	.006	.145	2.6	109.5	76

TABLE 71.—*Analyses of water from West Branch of the Housatonic at Pittsfield.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
June 26	Slight	1.5	0.268	0.084	0.001	0.010	1.5	76.5	46
July 27	do	.8	.216	.004	.000	.000	2.4	83.5	53
September 14	Decided	1.5	.432	.008	.000	.020	2.8	92.5	63
September 25	do	2.0	.452	.012	.002	.010	3.2	104.0	63
October 23	do		3.260	.970	.000	.010	15.6	458.0	89
November 20	do	2.1	.410	.080	.003	.060	2.2	102.0	60
December 18	do	.8	.328	.140	.019	.090	1.8	103.5	79
Average		1.4	.821	.209	.031	.031	4.4	155.3	65

TABLE 72.—*Analyses of water from Southwest Branch of the Housatonic at Pittsfield.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
June 26	Slight	0.9	0.376	0.372	0.016	0.040	2.3	96.5	61
July 27	do	1.4	.210	.100	.004	.060	1.2	137.5	103
September 14	Decided	1.3	.434	.064	.012	.020	1.8	154.0	96
September 25	do	1.2	.440	.092	.005	.010	2.5	144.0	94
October 23	do	1.5	.364	.304	.007	.080	2.6	180.5	123
November 20	do	2.0	.284	.180	.006	.340	2.3	180.0	126
December 18	None	.8	.072	.036	.002	.420	1.8	116.5	97
Average		1.3	.291	.166	.007	.159	2.0	144.3	101

The analyses set forth in Tables 70, 71, and 72 represent the character of the water furnished to the Housatonic River. It will be seen that every branch which contributes to form the main artery at Pittsfield is highly polluted, and therefore the Housatonic at the very outset is a badly damaged stream. The West Branch seems to be in the foulest condition, the East Branch closely following. Nearly all

the pollution in the West and Southwest branches is furnished by the city of Pittsfield. The upper reaches of these two streams remain in excellent condition.

Pittsfield, a city of 21,766 inhabitants, has a public water supply and a system of sewerage which empties into the three branches of the river. During the period in which the analyses in Tables 70, 71, and 72 were made a sewage-purification system for the city of Pittsfield was in course of construction, and when this is put into operation a large part of the sewage which now enters the river will be no longer a source of pollution.

Passing down the river we find that the next available analyses of Housatonic River water were made from samples taken at New Lenox, a point about 4 miles below Pittsfield. The drainage area of the river at this point is 145.6 square miles, the population being about 177 per square mile. The following table comprises the average result of monthly examinations of the water at this point since the year 1894:

TABLE 73.—*Analyses of water from Housatonic River at New Lenox.*

[Parts per million.]

Year.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1894	2.7	0.183	0.131	0.024	0.204	2.5	131.7	85
1895	2.6	.238	.183	.038	.173	2.5	117.3	84
1896	2.6	.192	.169	.036	.208	2.2	118.8	86
1897	3.2	.240	.159	.008	.203	1.9	107.9	75
1898	2.7	.223	.106	.008	.178	1.5	94.0	64
1899	2.0	.233	.197	.017	.132	2.3	107.6	74
1900	2.2	.278	.378	.018	.118	2.8	111.7	72

Comparison of Table 73 with the three preceding tables shows that very little change has taken place in the amount and character of the organic matter in the river after it has traversed the 4 miles above mentioned. The water seems to be fairly loaded with polluting material in every state of oxidation, and there seems to be extremely rapid decomposition going on. There is nothing of an unusual nature in the above series. They present and clearly indicate an abundant pollution, which, as we have seen, is borne out by facts.

Leaving New Lenox the river flows south past the town of Lenox, which has a population of 2,942. At this place there is a sewerage system, but it is provided with a disposal plant, so that the river does not receive a large increment of pollution. A few miles farther down

the river runs through the town of Lee, which contains 3,956 inhabitants. Considerable polluting matter is poured in at this point. Shortly below Lee the river makes a sharp turn eastward and flows through Stockbridge, a town which has a population of 2,031. A sewerage system is maintained at this point and filter beds have been provided, so that extensive pollution of the river is avoided.

TABLE 74.—*Analyses of water from Housatonic River at Stockbridge.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
June 26	Very slight	1.1	0.312	0.284	0.016	0.070	2.9	120.5	96
July 31	do	.8	.198	.174	.014	.100	2.6	171.0	83
August 27	Decided	1.5	.240	.208	.026	.022	3.3	136.0	93
September 26	Very slight	1.2	.192	.072	.012	.110	3.9	135.0	103
October 23	do	1.5	.236	.228	.018	.220	4.4	166.5	117
November 21	Decided	3.5	.380	.208	.007	.210	3.7	123.5	86
Average		1.6	.260	.195	.005	.152	3.5	133.1	96

After leaving Stockbridge the river again turns south and flows through the town of Great Barrington which has a population of 5,854 and which contributes a large amount of pollution.

The next series of analyses made by the Massachusetts State Board of Health is of the water from the river at Sheffield, just north of the Connecticut State line. There seems to be considerable improvement in the water at this point over that at Stockbridge. The average of the six analyses of the water from the river made during the year 1900 is set forth in the following table:

TABLE 75.—*Average of six analyses of water from Housatonic River at Sheffield.*

[Parts per million.]

Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	Number of samples.
	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.				
1.6	0.214	0.079	0.004	1.93	2.8	128.2	90	6

The above average of analyses clearly indicates a fairly large degree of purification over that shown in Table 74. It will be seen that while the color and residue are practically the same, the free and albuminoid ammonia and the nitrites are considerably less, while the nitrates are higher—an unmistakable indication of oxidation. The chlorine, too, seems to be in smaller proportion, the river having been largely diluted by the influx of pure water.

Passing over into the State of Connecticut the Housatonic runs by or through the towns of Salisbury and North Canaan, where the population is almost entirely rural, although these places are rather thickly settled.

At Falls Village, a few miles south of the Massachusetts border, the Board of Health of the State of Connecticut has during the year 1900 been securing samples of water for analysis the results of which are set forth in the following table:

TABLE 76.—*Analyses of water from Housatonic River at Falls Village, Conn.*

[Parts per million.]

Date of examination.	Turbidity.	Color	Nitrogen as—				Chlorine.	Total residue.	Hardness.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.									
January 26	Slight	0.3	0.192	0.044	0.002	0.15	1.7	79.0	60
February 22	Distinct	.2	.102	.042	.002	.10	1.9	86.0	70
March 21	Very slight	.3	.170	.018	.004	.15	1.6	69.0	35
April 30	None	.2	.082	.046	.002	.05	1.8	67.0	75
May 17	Slight	.3	.188	.070	.008	.05	2.0	62.5	60
June 11	do	.2	.174	.090	.001	.10	2.1	111.0	90
July 5	None	.2	.112	.028	.003	.10	2.7	125.0	70
August 14	Slight	.1	.118	.024	.002	.18	2.9	131.0	63
September 12	do	.3	.207	.026	.004	.13	2.1	115.0	55
October 10	do	.2	.100	.020	.002	.13	4.0	145.5	68
November 13	do	.4	.148	.012	.002	.22	3.3	139.5	53
December 10	do	.4	.146	.034	.006	.20	1.6	106.0	59
Average		.3	.150	.038	.003	.13	2.3	103.0	63

Comparison of the above series with that made of the water at Sheffield, Mass., shows a still further purification. In some respects the water at Falls Village is considerably better than at any point since it received its first contamination at Pittsfield. One can not fail to be impressed with the fact that the Housatonic has excellent

powers of recovery, and it is very likely that if the sewage of the various towns along its banks is submitted to proper treatment the river will approach nearly its normal purity.

The State Board of Health of Connecticut has conducted another series of analyses of the water at a point 65 miles below the town of Falls Village, at the town of Derby, just below where the Naugatuck joins the river. In passing from Falls Village to Derby the Housatonic goes by the towns of Sharon, Cornwall, Kent, New Milford, Bridgewater, Brookfield, Roxbury, Southbury, Oxford, Newton, Monroe, Seymour, and Huntington. All these municipalities contain from 1,000 to 3,000 inhabitants, and contribute an amount of contaminations usual in such cases. In addition to these towns there is the city of Danbury, with a population of 16,000, which contributes raw sewage in large amount. In spite of this additional pollution, however, the analysis made at Derby shows very little change in the character of the water.

TABLE 77.—*Analyses of water from Housatonic River at Derby.*

[Parts per million.]

Date of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1900.								
January 29	0.3	0.122	0.052	0.002	0.10	2.3	79.0	60
February 21	.3	.108	.040	.002	.10	2.1	60.0	40
March 21	.3	.128	.050	.040	.15	1.9	51.5	27
April 26	.3	.124	.036	.002	.05	2.3	75.5	45
May 17	.3	.108	.060	.006	.15	1.9	80.5	70
June 11	.3	.100	.078	.002	.15	2.3	99.0	80
July 5	.2	.144	.050	.002	.05	2.4	108.5	70
August 24	.2	.140	.040	.000	.10	2.3	115.5	57
September 11	.2	.144	.026	.060	.05	2.8	116.5	91
October 10	.1	.144	.036	.001	.10	3.6	116.0	58
November 4	.5	.188	.016	.004	.19	3.5	113.5	36
December 10	.4	.168	.006	.006	.20	1.9	82.5	43
Average	.3	.136	.042	.008	.13	2.44	91.5	56

Below Derby the Housatonic receives the polluted water of its principal tributary, the Naugatuck, and flows thence into Long Island Sound. We have now traced the river from its source in Massachusetts to its mouth, and have found that from its headwaters it is

polluted to a sufficient extent to entirely unfit it for a source of water supply unless the water is filtered. This, however, is about as far as damage extends. Although considerable sewage enters the river at different points, such is the dilution and such the purifying capacity that it does not, except at a few points, betray its contamination, except by chemical analyses. As it crosses from Massachusetts into Connecticut it is in a condition which makes its use by the people of Connecticut as a source of water supply impossible without filtration. It is probable that the Housatonic River will in the future be constantly improved by the removal of sewage contamination through the establishment of purification works at the various points of pollution.

COURT DECISIONS IN CONNECTICUT.

The opinion of the supreme court of errors of the State of Connecticut in a suit at law against the city of New Britain, arising from the pollution of a watercourse, has already been cited. The courts of Connecticut have taken no uncertain stand on the question of river pollution. In no other State in the Union has there been such unequivocal judicial disapproval of the practice of destroying water resources, and as future work along this line will probably result in frequent reference to the Connecticut cases it seems wise to review briefly the different decisions which have been rendered.

The case of Morgan *v.* The City of Danbury is of interest, inasmuch as it involves a decision against a city which had provided a purification plant for the disposal of sewage. The plaintiff, a riparian owner and a mill proprietor on Still River, complained in the superior court that the defendant, without making him any compensation or attempting to acquire any of his rights, did discharge and was continuing to discharge into that river wastes, sewage, and other noxious substances, and prayed for an injunction against the continuance of that practice.

Danbury is a city of 20,000 inhabitants, situated on Still River, a small sluggish stream which empties into the Housatonic 16 miles below. In 1885 a system of sewerage was constructed which emptied directly into Still River. By the year 1890 the use of the sewers had increased to such an extent as to cause a local nuisance. In 1893 an outfall sewer was completed which conducted the sewage 1 mile below the city. During the summer seasons Still River has scarcely any flow, and the Woolf disinfecting system was installed in 1894, for use during the dry stages of the river. It consisted of large vats of brine, from which a solution known as hyperchloride of sodium was developed by electric currents.

An injunction was granted against further discharge of sewage. An appeal was taken.

The case was reviewed by the supreme court of errors in the January term in the third judicial district, 1896, and following are

extracts of the opinion of the court handed down by Associate Justice Baldwin (67 Conn., 484):

The complaint alleged that the city was discharging waste matter, sewage, and other noxious, corrupt, and impure substances from its sewers so as to pollute the river and to cause much of such discharges to be deposited on the plaintiff's land and mill privilege; and that thereby he had been largely deprived of the use of a valuable mill and mill privilege, he and his workmen injuriously exposed to noxious odors, the air in the neighborhood corrupted and poisoned so as to endanger the health of himself and others, his milldam partly filled up with filth, the value of his property greatly diminished, and he disabled from disposing of his land for building purposes. * * *

These allegations were denied, but have been found true; and there is nothing inconsistent with their truth in the special finding of facts. * * * It was proper that an injunction should be so framed as to protect the plaintiff against every serious and irreparable injury which he might suffer by the continuance of the nuisance, and its terms are fully conformable to the claims stated in his complaint.

* * * The supplemental answer, setting up the establishment of the Woolf disinfecting plant, avers that the discharges from the sewer have thereby been rendered "entirely harmless and free from any offensive qualities, and no solid matter is permitted to empty from said sewer into said stream, but the same is liquefied and clarified and the plaintiff is relieved thereby of all danger in the future from the said sewer." * * * These allegations were denied, and the issues upon them have been found for the plaintiff.

* * * It is not impossible that fluids discharged from the sewer, although colorless, sterilized, and apparently innoxious, may yet be such as, by combination with other substances found in the river, to become the occasion of decomposition and consequent pollution. * * *

The defendant urges that it should not be made responsible for the acts of others, and that if its sewage is thoroughly disinfected, sterilized, and purified before its discharge into the river, nothing further should be required, even though, as it flows down the stream, it may be brought into contact with other substances in such a way as to work a nuisance. But the right to deposit a thing in any place must always be dependent, not only on its own nature but on the nature of the place in question and the uses to which that has already been put.

In a similar suit brought by Platt Bros. & Co., to restrain the city of Waterbury from polluting Naugatuck River above the complainant's mill, the superior court rendered judgment for $500, and an injunction was issued. Appeal was made by the State to the supreme court of errors, and a decision was handed down January 4, 1900, by Associate Justice Hammersley. This opinion deals so clearly and admirably with that oft-repeated contention of municipal authorities that a city is not liable for damages because of sewage, if it has been authorized to turn the same into a stream by an act of the legislature, that a large part of the decision will be given here (72 Conn., 531):

The main contention of the defendant may be stated in this way: The use of the sewers, under authority of the legislature, in the manner described, is a public, governmental use; the injuries to the plaintiffs result from this governmental use and are not direct but merely consequential; the victim of consequential injuries resulting from a governmental use is entitled to no remedy unless one is given by statute; the defendant's charter provides no remedy for consequential injuries

resulting from the use of said sewers; ergo, the plaintiff has no remedy, and its damage is damnum absque injuria.

The premises essential to this conclusion are untrue. A governmental use may include any act which the State may lawfully perform or authorize. There are, however, governmental acts to which certain immunities attach; and it is with this restricted meaning that the phrase is used by the defendant. In this sense a governmental act is one done in pursuance of some duty imposed by the State on a person, individual or corporate, which duty is one pertaining to the administration of government, and is imposed as an absolute obligation on a person who receives no profit or advantage peculiar to himself from its execution. It is the State, exercising its governmental power through an agent who, in this matter, is the agent of the State and nothing more. It is to be distinguished from a large class of governmental acts which the State, by way of grant or special privilege, authorizes persons to perform in part for their personal benefit. The principal immunities belonging to a governmental act, in this restricted sense, are: (1) Freedom from personal responsibility for the consequences of the act done. So long as a lawful mandate of the State is faithfully executed, the agent acting within the scope of that authority enjoys the exemption from suit which belongs the State. (2) Freedom from personal responsibility for the negligence of his servants. The rule of respondeat superior does not apply, because the agent of the State is not the superior: the real superior is the State itself.

The defendant claims these immunities. It may be doubted whether the use of sewers under the charter of the defendant, for the collection and disposition of refuse belonging to its citizens, is a governmental act within the definition given. The charter authorized the construction of sewers for that purpose, but no absolute duty was imposed upon the city; action in pursuance of the authority was at its option and could not have been enforced by any process of law without further legislation. While sewers or drains for the disposition of surface waters collecting in highways may be considered as mere adjuncts of a highway, partaking of its nature as a governmental use (Cone *v.* Hartford, 28 Conn., 363, 372), it is different with sewers for the disposition of refuse and filth accumulated upon private property. The disposition of such stuff is in part for the benefit of the property holder. The city represents, in such respects, the interests of its inhabitants, and is granted certain special powers, in part for the promotion of their interests (Bronson *v.* Wallingford, 54 Conn., 513, 519). It is well settled that there is a clear distinction between those governmental duties imposed upon a city as a mere agent of government and those governmental powers granted as a privilege primarily for the personal benefit of its inhabitants. * * * We think it evident that the mere granting authority to a city to construct, for the convenience and benefit of its inhabitants, sewers adapted to carry off their refuse matter to some neighboring stream, does not necessarily make such use of the sewers a governmental use in the sense indicated. * * *

But if, for the purpose of this case, we concede the defendant's claim that the use is a governmental use, it is nevertheless liable to the plaintiff. The injury described by the complaint is not a mere consequential damage, like that resulting wholly from the lawful use of one's own property, or the lawful exercise of governmental power; it is a direct appropriation of well recognized property rights within the guarantee of the Constitution—"The property of no person shall be taken for public use without just compensation therefor" (Nolan *v.* New Britain, supra, p. 681), and so the defendant's claim that its charter does not authorize the condemnation of the plaintiff's property rights is immaterial. Upon a careful examination of the charter as enacted in 1871 (7 Special Acts, 206) and amended in 1881 (9 id., 233 et seq., 237), in 1883 (9 id., 839), and in 1884 (9 id., 954), and applying the rule which requires a law to be so construed, if reasonably possible, as to

give it validity, we think the city is authorized to make compensation by agreement or after appraisal, for any private property taken for the purpose of the maintenance and use of the sewers authorized. But if it were otherwise, the defendant would not be benefited. Its whole defense of acting under lawful State authority would then fail, and the mere finding of the facts alleged in the complaint would clearly support the judgment.

The defendant's brief presents its claim in a form somewhat different from that stated in the finding, and certainly novel in this State. It is substantially this: (1) A riparian city has a right to use the river for certain drainage, and such surface drainage necessarily pollutes the water to some extent, increasing with the growth of the city. (2) The use of these legitimate drains to carry off the noxious refuse accumulated by its inhabitants becomes in time an absolute necessity. (3) The right of surface drainage is thereby enlarged so as to include the right to discharge into the river, by means of these drains, such noxious refuse. Therefore the necessities of municipal growth give the city a right to convey these noxious substances to the property of downstream proprietors, and so to appropriate that property for public use without compensation.

It is unnecessary now to discuss the limitations to the right of surface drainage, for the second and third propositions are clearly wrong. The right to pour into the river surface drainage does not include the right to mix with that drainage noxious substances in such quantities that the river can not dilute them nor safely carry them off without injury to the property of others. The latter act is, in effect, an appropriation of the bed of the river as an open sewer, and the proposition that it may become lawful by reason of necessity is inconsistent with undoubted axioms of jurisprudence. The appropriation of the river to carry such substances to the property of another is an invasion of his right of property. When done for a private purpose it is an unjustifiable wrong. When done for a public purpose it may become justifiable, but only upon payment of compensation for the property thus taken. Public necessity may justify the taking, but can not justify the taking without compensation. It may be necessary for a city to thus mix with its drainage such substances, but it is not necessary to pour such mixture into the river without purification; indeed, the purification is coming to be recognized as a necessity. But however great the necessity may be, it can have no effect on the right to compensation for property taken. The mandate of the Constitution is intended to express a universally accepted principle of justice, and should receive a construction in accordance with that principle, broad enough to enable the court to protect every person in the rights of property thus secured by fundamental law.

There are certain apparent, but not real, exceptions to this protection. Emergencies may be such as to justify the taking of property without waiting to provide for compensation; property may be destroyed without compensation in certain cases when used unlawfully, or when it has become a thing of danger. But this is not a case of war or conflagration. The plaintiff has not so used its property as to subject it to the harsh police power of confiscation. The plaintiff has certain rights as a riparian landowner. These rights are property within the meaning of our constitutional guaranty, and an invasion of these rights such as the defendant has made is a taking of that property. The legislature has no power to authorize such taking except for public use, and then only upon providing for just compensation. (Kellogg *v.* New Britain, 62 Conn., 232, 239; Wadsworth *v.* Tillotson, 15 id., 366, 373; Harding *v.* Stamford Water Co., 41 id., 87, 93; Nolan *v.* New Britain, 69 id., 668, 681; Fisk *v.* Hartford, 70 Conn., 720, 731; Seifert *v.* Brooklyn, 101 N. Y., 136; Chapman *v.* Rochester, 110 id., 273, 277.)

An action for fouling a brook and mill privilege by the discharge of sewage, with a claim for damages and an injunction against the town of New Milford, was brought by Joseph E. Watson et ux. in the

superior court in Litchfield County, and on trial by the court (Shumway, J.) an injunction was refused and judgment was rendered for the plaintiff for $50 damages. An appeal was taken by the defendant for alleged errors in the rulings of the court. No error.

The finding stated these facts:

The plaintiffs' land is situated on Great Brook, in New Milford. There are no buildings on it. To use it for buildings would require some previous filling on a part of it. It has been used for pasturage, and partly for cultivation, but yields now little income. The annual rental value is $75, and has not been substantially affected by the fouling of the brook. The court, at the request of the parties, viewed the premises, in the summer, when the water was low, and saw on the margin of the brook a sediment giving off odors of putrefying sewage, unwholesome and offensive, and also undissolved constituents of house sewage lying on the ground, offensive to the sight. At times of high water such conditions would not exist.

Since 1876 the sewage from the town hall had been discharged through a drain constructed by a village improvement association into Great Brook above the plaintiffs' land. In 1893 all the school districts in the town were consolidated, and the town took charge of the public schoolhouses then erected. One of these then discharged its sewage into Great Brook, and has ever since.

The plaintiffs lived seven miles from their land in question. The waters of the brook, where it runs through it, are potable by cattle, and there are trout in it. This water privilege has no value in its present condition.

In 1893 the defendant extended certain sewers through the plaintiffs' land and into the brook thereon, and has since maintained the same. These serve to carry off the surface water from the streets, and also house sewage. Various houses have been connected with them for the discharge of their sewage into them, with the knowledge of the selectmen.

The town, by its use of the brook as a means of getting rid of the sewage from the town hall and schoolhouse, has, in connection with its use by citizens for carrying off sewage from their houses, caused the state of things viewed by the court. The damage thus caused is not irreparable, but an injunction would be a proper remedy to prevent multiplicity of suits, should the town continue such use of the plaintiffs' premises for an unreasonable length of time hereafter. It was not found that the nuisance had prevented them from effecting a sale of the property.

The case was reviewed by the supreme court of errors in the January term, in the first judicial district, 1900, and the following extract is from the decision handed down January 19, 1900, by Associate Justice Baldwin (72 Conn., 561):

A nuisance was created upon the plaintiffs' land by the deposit of sewage and sediment from sewage, offensive from its appearance or its smell. The use of the sewers which receive the surface drainage from highways, and of that built by the village improvement association, by the defendant, to carry off the sewage from its public buildings, contributed to this injury. That others also contributed to it, and perhaps more largely, did not relieve the town from liability. (Morgan *v.* Danbury, 67 Conn., 484, 496.)

That the plaintiffs suffered no personal inconvenience from the nuisance, because they did not reside in the vicinity, is immaterial. They were entitled to nominal damages, at least, for the offensive condition of things upon their land, even if they never visited it, and although its rental and selling value remained unimpaired. (Watson *v.* New Milford Water Co., 71 Conn., 442.) If those assessed

can be regarded as substantial, they are still so small in amount that no new trial should be granted for their reduction. (Buddington *v.* Knowles, 30 Conn., 26; Holbrook *v.* Bentley, 32 id., 502, 508.)

The action was well brought against the defendant as a town, and not as a consolidated school district. It is a single corporation, and the consolidation simply threw upon it additional powers and duties. It maintained as a town a nuisance previously created by a district.

That the plaintiffs in prior years had discharged sewage and dyes from a hat shop on their premises into the brook did not bar their right of recovery. If they had thus fouled the brook to the injury of landowners below them, it did not operate as a license to landowners above them to use it in a similar way.

That the water remained potable by cattle and inhabitable by fish was unimportant except in mitigation of damages.

DELAWARE RIVER.

The Delaware drainage area occupies parts of the States of New York, New Jersey, and Pennsylvania, comprising 6,855 square miles. (See fig. 12.) The main river of the Delaware system rises in New York State, in a county bordering the western part of the Catskill Mountains. The elevation at that point is said to be about 1,900 feet. It flows in a very irregular course, its general direction being southward, and empties into Delaware Bay. For about 100 miles above Port Jervis it forms the boundary between the States of New York and Pennsylvania; below that point it forms the entire western boundary of the State of New Jersey.

The principal tributaries of Delaware River enter from the west. They consist of the Schuylkill, which joins the main stream at Philadelphia, draining a country 1,912 square miles in extent; and, a little farther north, the Lehigh, at Easton, the basin of which, 1,332 square miles in extent, comprises a great mining region of Pennsylvania. The Lackawaxen River enters at Lackawaxen, draining in its course 597 square miles. At the extreme northwestern part of the Delaware basin the river forks into the East and West branches, which drain 520 and 348 square miles, respectively.

Although the drainage basin of the Delaware is a very important, prosperous, and thickly-settled region, the resources of the river system have not been utilized or appreciated to any considerable extent, and comparatively little has been done to determine the character of the water. At Philadelphia the city is now conducting extensive investigations, which, when their results become available, will furnish a clear insight into the character of the water in the Schuylkill and Delaware opposite that city. Aside from these investigations, the results of which can not be learned at present, the only data available are comprised in a short report, by Mr. Allen Hazen, on the character of the water supply of the city of Trenton, N. J., which demonstrated beyond controversy that the water of the Delaware above the city of Trenton is polluted with sewage and industrial refuse to a dangerous degree.

FIG. 12.—Delaware River drainage basin.

The following table, taken largely from Mr. Hazen's report, gives the names of the municipalities in the Delaware Basin above Trenton contributing polluting substances to the river:

TABLE 78.—*Cities and towns above Trenton contributing polluting substances to Delaware River.*

[Drainage area, 6,916 square miles.]

City or town.	County.	Distance above Trenton.	Population, 1910.
		Miles.	
Lambertville, N. J	Hunterdon	14	4,637
Newhope, Pa	Bucks	14	1,218
Frenchtown, N. J	Hunterdon	30	1,020
Quakertown, Pa	Bucks	42	3,014
Phillipsburg, N. J	Warren	47	10,052
South Easton, Pa	Northampton	48	25,238
Easton, Pa	do	48	
Bangor, Pa	do	56	4,106
Nazareth, Pa	do	58	2,304
Bethlehem, Pa	do	59	7,293
South Bethlehem, Pa	do	59	13,241
West Bethlehem, Pa	Lehigh	60	3,465
Washington, N. J	Warren	60	3,580
Belvidere, N. J	do	62	1,784
Allentown, Pa	Lehigh	64	35,416
Penn Argyl, Pa	Northampton	65	2,784
Catasauqua, Pa	Lehigh	67	3,963
Oxford, N. J	Warren	71	3,095
East Stroudsburg, Pa	Monroe	71	2,648
Slatington, Pa	Lehigh	79	3,773
Stroudsburg, Pa	Monroe	81	3,450
Lehighton, Pa	Carbon	90	4,629
East Mauchchunk, Pa	do	93	3,458
Mauchchunk, Pa	do	93	4,029
Summithill, Pa	do	95	2,986
Nesquehoning, Pa	do	98	2,862
Waverly, Pa	do	100	2,471
Newton, N. J	Sussex	105	4,376
Whitehaven, Pa	Luzerne	115	1,517
Hazleton, Pa	do	115	14,230
Port Jervis, N. Y	Orange	120	9,385
Hawley, Pa	Wayne	157	1,925
Honesdale, Pa	do	166	2,864

TABLE 78.—*Cities and towns above Trenton contributing polluting substances to Delaware River*—Continued.

City or town.	County.	Distance above Trenton.	Population, 1900.
		Miles.	
Hancock, N. Y	Delaware	194	1,883
Deposit, N. Y	do	205	2,051
Walton, N. Y	do	228	2,811
Delhi, N. Y	do	245	2,078

Although only a few of the municipalities mentioned in the above table have been provided with sewers, and the pollution is therefore in an early stage of its development, the effects are noticeable in the following analyses, which were made during the period of Mr. Hazen's investigation:

TABLE 79.—*Analyses of water from Delaware River at Trenton.*

[Parts per million.]

Date.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Iron.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
Apr. 16	3	0.15	0.060	0.004	0.000	0.260	1.7	44.50	23.0	6.0	0.30
June 29	680	.18	.350	.040	.004	.160	1.6	480.00	27.0	8.0	11.80
July 6	7	.12	.088	.042	.003	.320	2.2	93.00	42.0	9.5	.05
July 27	480	.12	.226	.086	.004	.160	2.0	273.00	27.0	9.5	8.00
Aug. 17	3	.11	.102	.018	.006	.160	2.8	116.00	57.0	7.5	.20
Sept. 13	8	.08	.116	.024	.004	.160	3.0	103.00	57.5	14.0	.30

The investigation included a daily determination of turbidity from April to November, inclusive, in the year 1889, the results of which show that the Delaware water is usually free from suspended matter, and that, although it carries along considerable mud during freshets, subsidence is rapid.

TABLE 80.—*Turbidity of Delaware River at Trenton.*

Day of month.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	.....	6	6	9	13	6	6	6
2	.....	6	6	9	13	6	6	6
3	.....	6	9	6	9	6	6	6
4	.....	6	9	6	13	6	6	6
5	.....	6	9	6	6	6	6	6
6	.....	6	9	6	6	6	6	6
7	.....	6	9	6	6	6	6	6
8	.....	6	6	28	6	6	6	6
9	6	6	6	13	6	6	44	13
10	6	6	6	9	6	6	6	9
11	6	6	6	6	6	6	6	6
12	6	6	6	6	6	6	6	6
13	6	6	6	6	6	6	6	6
14	6	6	6	6	16	6	400	6
15	6	6	77	6	6	6	100	6
16	6	6	77	6	6	150	56	6
17	6	6	32	6	6	32	13	6
18	6	6	32	6	6	20	6	6
19	32	2,737	28	6	6	13	6	6
20	28	28	16	6	6	9	6	6
21	16	28	9	6	6	9	6	6
22	16	28	6	6	6	6	6	6
23	16	24	6	6	6	6	6	6
24	16	24	6	6	6	6	6	6
25	13	9	6	6	6	6	6	6
26	13	9	6	28	6	6	6	.....
27	13	9	6	77	6	6	6	.....
28	9	9	236	56	6	6	6	.....
29	9	9	16	40	6	6	6	.....
30	6	6	16	32	6	6	6	.....
31	.....	6	.....	150	6	.....	6	.....

OHIO RIVER BASIN.

DRAINAGE AREA.

A clear and concise description of the drainage area of the Ohio River is given in the report of Prof. Dwight Porter, published in Volume XVII of the Report of the Tenth Census, as follows:

By the union of the Allegheny and Monongahela rivers at Pittsburg the Ohio River is formed, with a drainage basin at that point of between 18,000 and 19,000 square miles, which, after a course of nearly a thousand miles to the southwest,

is increased to about 214,000 square miles at the junction with the Mississippi. The principal streams which contribute to this increase are, on the north side, the Beaver, Muskingum, Scioto, Great Miami, and Wabash rivers, and on the south side the Little Kanawha, Great Kanawha, Big Sandy, Licking, Kentucky, Green, Cumberland, and Tennessee. The headwaters of the Allegheny are in northern Pennsylvania and southwestern New York; those of the Monongahela, nearly 250 miles distant, in West Virginia. The eastern watershed line of the Ohio therefore cuts directly across the State of Pennsylvania, at a distance from the western border ranging from 80 miles in the south to about 130 miles in the north. Passing out of this State, the northern boundary of the river basin runs through New York, Ohio, and Indiana, being carried in the latter State around the upper waters of the Wabash nearly to the Michigan line and considerably more than 200 miles north of the main river itself; it then enters Illinois and strikes southerly through that State to the mouth of the Ohio at Cairo. The southern boundary runs from Pennsylvania across a corner of Maryland, embraces nearly all of West Virginia, and forms in part the dividing line between that State and Virginia; it crosses the southwestern portion of the latter State and the western part of North Carolina, and by the Tennessee Basin is extended down into Georgia and Alabama, reaching there a distance of 300 miles south of the Ohio; it continues from Alabama across the adjacent northeastern corner of Mississippi, and finally traverses the extreme western portions of Tennessee and Kentucky.

The characters of the different streams within this area are determined or modified by the various topographic features of the country. In the east and southeast the drainage area is bordered by the Allegheny Mountains, and the streams which have their origin there flow into the Ohio through a generally sparsely settled country rich in mineral deposits. From this region across to Mississippi River the surface grows flatter, rapidly in some directions, more gradually in others. Toward the Ohio there is a gradual decline in elevation, culminating in the bottom lands along that river, which have become famous for their fertility. North of Ohio River the land comprising that portion of the basin lying within the States of Ohio and Indiana rises very slowly, through many miles of undulating territory, and ends in a low range of hills which forms the divide between the Ohio Basin and the drainage area of the Great Lakes.

The various tributaries on the south side of the Ohio offer facilities for extensive development of power. The descent of the streams is swift, especially in the southern portion, but the flow is extremely variable, the drainage areas being of the "quick-spilling" variety, and consequently enormous pondage would be necessary to secure any great measure of uniformity of flow. In the case of some streams this would make the initial cost of utilization extraordinary and prohibitive. On the north side of the Ohio the country is flat and the proportion of run-off is small, so that, as a whole, the streams are not well adapted for the development of power. It is true that there has been considerable utilization of streams for local grist and lumber mills, yet it is not at all proportional to the contributing drainage area as compared with that which is possible on the streams of New

York and New England. The Ohio is therefore in only a comparatively limited sense a power stream.

The main river has great value as a channel of transportation, and some of the tributaries are navigable to a limited extent. This value has been developed largely by the Federal Government.

CHARACTER OF WATER.

In considering the characteristics of the waters of the Ohio Basin one can not fail to be impressed with the marked differences which exist between them and the waters of the Northeastern States, already considered at length. In the latter region we have studied waters which are, as a rule, fairly clear, which contain only small amounts of dissolved mineral matter, and in which the degree of hardness is usually almost insignificant. We have noted that the New England waters are highly colored, some extremely so, from the solution of chlorophyll and decaying vegetable and peaty matter. This characteristic has led to the application to these waters of the apt and expressive term "vegetable tea." In considering the water in the Ohio Basin it is necessary to remember in the beginning that we have to deal with a water which usually contains a high proportion of inorganic salts, which is hard, and which in times of freshet carries along enormous quantities of fine clay and mud. A report of a water analysis which, in the case of a New England water, would be regarded as certain evidence of artificial pollution, may in the case of Ohio water represent a truly normal river of uncontaminated and healthful character.

The following analyses illustrate this point:

TABLE 81.—*Comparison of analyses of normal waters in New England and in the Ohio Basin.*

[Parts per million.]

	Region.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			
1	Massachusetts	Very slight.	6.6	0.199	0.013	0.000	0.037	1.7	34.7	8.0
2	Ohio Basin	do	4.0	.514	.062	.024	1.500	2.0	730.0	43.6

Sample No. 1 in the above series was a normal water taken from an upland stream in Massachusetts. It is a fair representative of Eastern waters, having some turbidity, a high color, and considerable organic matter, as is shown by the nitrogen compounds. Sample No. 2 was a normal water taken from an upland region in the Ohio Basin

above all points of contamination. It also is a good representative of waters of its class, having a moderate color, a large residue, and an extremely high content of nitrogen, especially in the form of nitrates. Note also that the water is very hard. From the standpoint of sewage pollution both of the above samples are equally good, each being uncontaminated. From the sanitary standpoint No. 2 is the equal of No. 1, and if these analyses faithfully represented the character of the streams from which these samples come the resources of one would be equal to those of the other, other things, of course, being equal.

Another point to be borne in mind is the extreme variability of the physical characteristics of the Ohio Basin waters, especially the turbidity. In a time of drought the water will be clear, but soon after a rainstorm the turbidity will rise to a point which almost defies clarification, but in the course of a few days the water will become as clear as it was before the storm.

ALLEGHENY RIVER.

GENERAL FEATURES.

Drainage area.—The Allegheny is the largest contributor to the Ohio. (See fig. 13.) The drainage area covers 11,400 square miles and lies principally in the State of Pennsylvania, extending for a short distance into the State of New York. The length of the stream is about 325 miles, and its basin embraces a large area of the western slope of the Allegheny Mountains. The country is rough and broken, with high summits and deep valleys.

Water power.—The Allegheny is not very valuable as a source of water power. The storage capacity in the drainage area is extremely small; and although in early times the large number of springs maintained a fairly constant flow, the deforestation has reduced the whole area to a "quick-spilling" country. Although the drainage area is large, only a small portion of it contains streams that are valuable for development of power. The river is peculiar in this respect, for the descent is more rapid in the middle and lower portions than it is at the headwaters. In those portions it is deep and is used extensively for transportation, but above the head of navigation it has little value. The power which has been developed is applied mainly to the lumber industry.

Flow.—The flow of the Allegheny has not been definitely determined, and the figures available to show it are not the result of as careful and long-continued measurement as is generally considered necessary for the accurate determination of flow.[a] Measurements made in 1897 under the direction of a corps connected with the War Department seem to show that the flow of the Allegheny at Franklin

[a] See Twentieth Annual Rept. U. S. Geol. Survey, Part IV, p. 195.

was about 1,000 second-feet, and at another point 20 miles below a discharge of 1,250 second-feet was determined. In the year 1838 the discharge of the Allegheny at Pittsburg was reported as being 1,330 second-feet, while various gagings during the years 1866–1870 showed

FIG. 13.—Allegheny River drainage basin.

that at Brunots Island, 2½ miles below the junction of the Allegheny and the Monongahela rivers, the least discharge was 1,700 second-feet.

POPULATION OF BASIN.

In the drainage basin of Allegheny River the population has increased rapidly. The following table includes the most important

cities and towns, their population in 1890 and 1900, and their approximate distance from the city of Pittsburg:

TABLE 82.—*Cities and towns on Allegheny River and tributaries above Pittsburg.*

Place.	Distance in miles.	Population.		Place.	Distance in miles.	Population.	
		1890.	1900.			1890.	1900.
Verona	3	1,477	1,904	Titusville	142	8,073	8,224
Oakmont	4	1,678	2,323	Meadville	144	9,520	10,291
New Kensington	11	.....	4,665	St. Marys	148	1,745	4,295
Tarentum	14	4,627	5,472	Johnsonburg	149	1,280	3,894
Freeport	21	1,637	1,754	Wilcox	151	.....	.....
Ford City	33	1,255	2,870	Tidioute	160	1,328	1,237
Apollo	35	2,156	2,924	Edinboro	161	1,107	691
Kittanning	38	3,095	3,902	Waterford	170	838	767
Saltsburg	47	1,088	828	Sheffield	172	2,202	2,580
Red Bank	57	2,035	1,961	Union	177	2,261	3,104
East Brady	62	1,228	1,233	Clarendon	180	1,279	1,092
Latrobe	64	3,589	4,614	Warren	181	4,332	8,043
Blairsville	65	3,126	3,386	Corry	195	5,677	5,369
Derry	72	1,968	2,347	Busti, N. Y	205	.....	.....
Parker	76	1,317	1,070	Jamestown, N. Y	210	16,038	22,892
New Bethlehem	77	1,026	1,269	Randolph, N. Y	212	1,201	1,209
Indiana	78	1,963	4,142	Salamanca, N. Y	222	3,692	4,251
Emlenton	82	1,126	1,190	Mayville, N. Y	227	1,164	943
Punxsutawney	85	2,792	4,375	Bradford	240	10,514	15,029
East Conemaugh	92	1,185	2,175	Olean, N. Y	241	7,358	9,462
Brookville	98	2,478	2,472	Cuba, N. Y	256	1,386	1,502
South Fork	99	1,295	2,635	Franklinville, N. Y	258	1,021	1,360
Clarion	100	2,164	2,004	Eldred	263	1,050	963
Ebensburg	112	1,202	1,574	Port Allegany	266	1,230	1,853
Reynoldsville	112	2,789	3,435	Smethport	267	1,150	1,704
Franklin	116	6,221	7,817	Coudersport	282	1,530	3,217
Du Bois	121	6,149	9,375				
Oil City	125	10,932	13,264				
Ridgway	140	1,903	3,515				

POLLUTION.

Inspection of the above table will show that although a great majority of the municipalities are small, and probably do not contribute a large amount of sewage or manufacturing wastes to the river, there are, nevertheless, many places that are probably sewered and that naturally pour their wastes into the river. There is no

record of any examination of the water of the Allegheny River except those made by the filtration commission of the city of Pittsburg.

The question of pollution has been considered in a report made by Prof. William T. Sedgwick to the Pittsburg commission, the conclusions of which were that the water is polluted to a degree which makes it unfit for use as a source of public supply in its raw state. This opinion is borne out by recent use of the water in Pittsburg. The records show that the typhoid fever rate is abnormal. Accordingly, the city of Pittsburg has investigated, and is even now preparing to introduce a system of filters, the total cost of which will not be far from $3,500,000, while the expense of maintenance is calculated in the report of Mr. Allen Hazen, consulting engineer, to be about $200,000 annually. This gives no idea of the damage done to the city of Pittsburg alone by sewage pollution. In a well-considered article published in the Pittsburg Dispatch April 21, 1902, it was estimated that the cost of treating typhoid fever and the value of the lives lost from that disease in the city of Pittsburg during the previous three years amounted to about $3,335,000, sufficient to pay interest upon and retire a bonded indebtedness of $13,000,000. These figures were charged to the account of typhoid fever alone, no estimate being made of the sickness and deaths arising from or induced by other water-borne diseases.

CHARACTER OF WATER.

Experiments were conducted during the years 1897–98, under the authority of the filtration commission, and throughout this period weekly chemical examinations were made of the water in the Allegheny River. These results are almost the only available ones which show the character of the water; and as the samples were taken a short distance above the city of Pittsburg, they show clearly what is being contributed to the Ohio system by this branch.

TABLE 83.—*Analyses of water of Allegheny River at Brilliant, above Pittsburg.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Iron.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1897.											
June	Decided	.....	0.137	0.006	0.000	0.175	24.0	141	.....	.....	.....
July	....do	.....	.347	.034	.001	.106	31.3	269	60.8	.....	1.84
August	Slight	.....	.210	.023	.000	1.050	20.3	90	40.5	13.9	.07
September	....do	3.7	.133	.019	.000	.650	27.0	131	46.3	4.0	.63
October	....do	2.3	.120	.017	.000	.550	38.1	177	50.9	4.0	.40
November	....do	2.9	.152	.019	.000	.700	31.5	197	35.1	3.8	.95
December	....do	3.0	.111	.015	.000	1.075	21.1	237	17.2	5.2	1.23

TABLE 83.—*Analyses of water of Allegheny River at Brilliant, etc.*—Continued.

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Iron.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1898.											
January	Slight	2.8	.074	.016	.000	.895	15.3	153	14.8	6.1	1.12
February	do	2.1	.099	.020	.000	1.425	14.6	119	17.3	8.6	.59
March	Muddy	2.4	.076	.015	.000	.487	12.9	140	17.5	9.7	.40
April	Slight	2.2	.077	.018	.000	.458	13.6	94	18.3	4.6	.41
May	Decided	3.0	.164	.015	.000	1.80	16.6	207	21.3	6.7	.33
June	76	2.5	.085	.019	.000	.375	24.2	191	31.0	4.0	.10
July	361	2.7	.100	.027	.000	.694	24.7	131	34.1	11.7	.20
August	105	3.1	.130	.214	.000	.495	24.2	195	31.5	8.4	.20

A mineral analysis made of the samples from the river collected September, 1898, gave the following results:

TABLE 84.—*Mineral analysis of water from Allegheny River.*

[Parts per million.]

Total solids	127.0
Loss on ignition	43.0
Calcium oxide	20.4
Magnesium oxide	4.9
Sulphuric acid	16.1
Chlorine	22.0
Silica	1.0
Iron oxide	.1

The analyses set forth in Table 83 certainly do not necessarily indicate a water of dangerous qualities. Albuminoid and free ammonia and nitrites are low, and on the whole the analyses present an extremely favorable appearance. This, then, is one of the cases in which, as stated in the introduction to this work, little can be determined concerning the dangerous qualities of a river from chemical examinations alone. Inspection of the map shows that the centers of contamination above Pittsburg on the Allegheny River are far removed from that city, and the distances intervening seem sufficient to bring about all the purification apparent in the result of the analyses above set forth; yet, as pointed out by Professor Sedgwick in the report already referred to, the velocity of the Allegheny is high, being at times from 7 to 8 miles an hour. Under such circumstances pollution poured into the river at Oil City, for instance, would reach Pittsburg with fifteen hours, and at a slower rate of flow would certainly arrive within a few days, at least. Now, it can be easily understood that although organic matter may be oxidized and diluted to such an extent that it would appear in an analysis in small proportion only, germs of disease entering the river with such pollution could arrive

at the Pittsburg water "intake" in a virulent condition. Undoubtedly such has been the case during all the years in which Pittsburg has suffered abnormal typhoid-fever morbidity.

Coincident with the examinations above described, other points along the Allegheny were made use of for the collection of samples. A series was collected at Montrose, the intake for the water supply of the city of Allegheny, 4 miles above Brilliant, at Pittsburg. Another series was taken at Hulton, where the intake for the supply of Oakmont and Verona is situated, 6 miles above Brilliant, and a third at Wildwood, 1½ miles above Brilliant, whence the water is taken to supply Wilkinsburg and the First Ward of the city of Pittsburg. These examinations, however, did not show that the water was materially different from that at Brilliant, and, indeed, when the rapid flow of the river is taken into account, this might have been expected. There were, however, a number of examinations of samples of water taken at Etna, 2 miles below Brilliant, on the opposite side of the Allegheny, below a point where a certain amount of pollution is received from Pittsburg, and another series of examinations of samples taken at Millvale, 4 miles below Brilliant, also on the opposite side of the river. The average of these examinations for each point is given in Table 85. It will be seen that these do not differ materially from the samples taken at Brilliant, even though the water is undoubtedly contaminated by the addition of Pittsburg and Allegheny sewage. The reasons for this will be discussed presently.

TABLE 85.—*Analyses of water from Allegheny River at Etna and Millvale.*

[Parts per million.]

Place of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Iron.	Number of samples.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal.		
Etna	2.9	0.119	0.030	0.000	0.682	18.6	155	32.7	5.6	0.70	35
Millvale	3.1	.149	.045	0.000	.706	25.8	147	47.0	8.5	.38	16

MONONGAHELA RIVER.

Drainage basin.—Monongahela River, which joins the Allegheny at Pittsburg to form the Ohio, has a drainage area of 7,625 miles. (See fig. 14.) It rises in the northern part of West Virginia and flows in a northerly direction, draining a part of the western slope of the Allegheny Mountains, most of which has a rugged character and lacks fertility. The region, once heavily timbered, has been very thoroughly cleared, except at the headwaters of the streams. The lower reaches of the river are fertile and yield a large crop of corn, but the country seems to be especially adapted to grazing.

Flow.—The flow of the Monongahela has not been determined in a manner more satisfactory than that of the Allegheny. In the year 1838 the flow of the Monongahela at Brownsville, 50 miles above Pittsburg, was reported to be only about 230 second-feet. This, however, was in a dry season. The lower reaches of the river constitute a "slackwater" basin, with a flow of not more than 1 foot per minute.

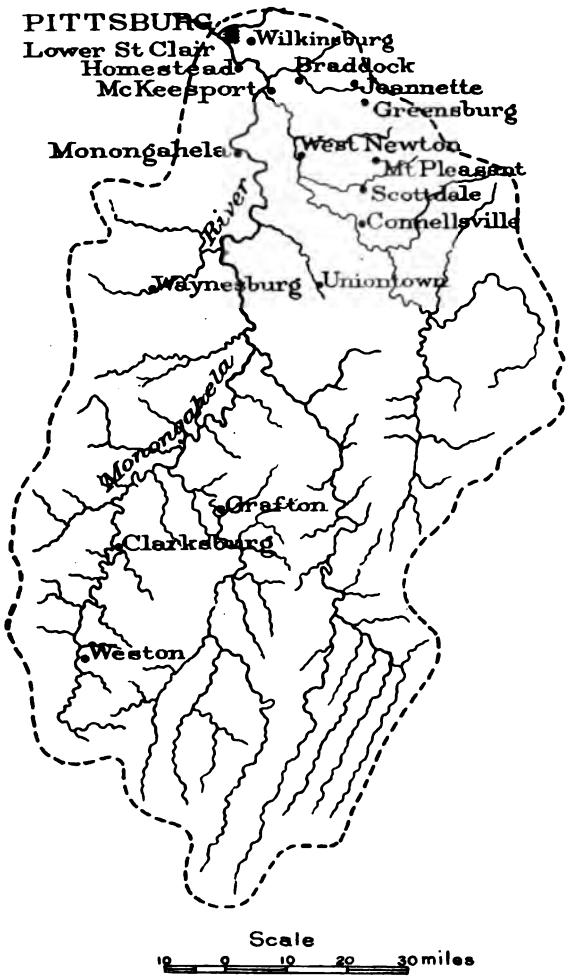

FIG. 14.—Monongahela River drainage basin.

Population of basin.—The population in the Monongahela Basin is denser than in the Allegheny, and there are larger cities, such as McKeesport, Homestead, Braddock, and Wilkinsburg, which are situated well down toward the mouth of the river. Therefore, the water which arrives at Pittsburg contains more recent pollution than that in the Allegheny. The important difference, however, lies in the fact that the flow of the Monongahela, as has been said, is slow, and there is the opportunity for sedimentation that arises in quiescent water.

TABLE 86.—*Cities and towns on Monongahela River and tributaries above Pittsburg.*

Place.	Distance in miles.	Population.	
		1890.	1900.
Lower St. Clair	3	3,680	4,638
Homestead	6	7,911	12,554
Braddock	9	8,561	15,654
Wilkinsburg	9	4,662	11,886
Port Perry	11	1,031	1,267
Turtle Creek	12	.....	3,262
Wilmerding	13	419	4,179
McKeesport	14	20,741	34,227
Elizabeth	20	1,804	1,866
Irwin	23	2,428	2,452
Jeannette	29	3,295	5,865
Monongahela	29	4,096	5,173
West Newton	32	2,285	2,467
Greensburg	33	4,202	6,508
Belle Vernon	41	1,147	1,901
Everson	50	.....	.....
Scottdale	52	2,693	4,261
Brownsville	52	1,471	1,552
Bridgeport	55	1,030	1,805
Mount Pleasant	57	3,652	4,745
New Haven	57	1,221	1,532
Connellsville	57	5,629	7,160
Dunbar	61	1,381	1,662
Uniontown	69	6,359	7,344
Waynesburg	80	2,101	2,544
Fairchance	95	1,092	1,219
Morgantown, W. Va	95	1,011	1,895
Somerset	112	1,713	1,834
Meyersdale	112	1,847	3,024
Fairmont, W. Va	120	1,023	5,655
Grafton, W. Va	140	3,159	5,650
Clarksburg, W. Va	150	3,008	4,050
Weston, W. Va	180	2,143	2,560
Buckhannon, W. Va	180	1,403	1,589

Character of water.—The increase of population, amounting to 75 per cent, as shown by the table presented above, is sure to bring about a proportional increase in pollution. It is not necessary to examine the water chemically or bacteriologically to prove that it is

unfit for use as a water supply. McKeesport, with a population of 34,227; Braddock, with 15,654; Homestead and Wilkinsburg, each following closely in the number of inhabitants, empty raw sewage into the Monongahela or its branches, and this must necessarily produce a condition which is a detriment not only to the water itself, but to the realty values along the river.

There are available a few analyses of the water of the Monongahela and some of the branches, which were made at Pittsburg at the same time as those already presented upon the Allegheny. A series of chemical examinations made of the water of Indian Creek and other creeks in its vicinity give a good idea of the character of the normal water of that section of the country, for the population on Indian Creek drainage area is small, is not at any point provided with sewerage, and is sufficiently well scattered to keep the water in its normal state, or nearly so.

TABLE 87.—*Analyses of water from Indian Creek and vicinity.*

[Parts per million.]

Place of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Iron.	Average of how many samples.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
Indian Creek	1.5	0.101	0.028	0.000	0.480	4.9	112	20.0	0.4	0.34	12
Mill Run	2.1	.128	.027	.000	.532	4.5	258	20.3	.5	.09	14
Laurel Hill Creek	1.7	.065	.039	.000	.675	3.9	35	20.7	.5	.01	3
Castleman River	1.7	.089	.055	.000	.750	4.6	84	15.3	5.3	.01	3
Youghiogheny River	1.5	.128	.082	.000	.975	3.5	40	17.6	.4	.01	2

Coming down to Pittsburg again, we find a series of analyses made of the water just above the city.

TABLE 88.—*Analyses of water from Monongahela River at Pittsburg.*

[Parts per million.]

Date of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Iron.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1897.										
June	.....	0.136	0.081	0.000	0.740	13.5	154	.....	.....	.....
July	.....	.186	.076	.001	.768	4.3	141	28.5	21.2	1.95
August	1.0	.173	.100	.001	1.121	10.7	129	19.5	37.8	1.93
September	2.6	.130	.119	.000	.979	9.5	145	16.4	41.5	.30
October	1.2	.403	.142	.000	1.261	15.5	285	9.0	55.2	.15
November	1.9	.194	.145	.000	.825	14.7	265	14.1	48.4	1.33
December	2.5	.166	.080	.000	1.275	13.1	328	14.3	17.2	2.72

TABLE 88.—*Analyses of water from Monongahela River, etc.*—Continued.

Date of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Iron.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1898.										
January	2.1	.095	.030	.000	1.245	9.1	298	13.8	15.2	2.06
February	2.0	.177	.021	.000	1.500	11.1	219	13.2	22.4	1.29
March	2.0	.080	.025	.000	.425	9.2	203	10.4	39.9	.28
April	2.1	.097	.018	.000	.450	8.2	127	11.5	12.0	.19
May	2.8	.125	.026	.000	.275	12.1	167	14.6	25.9	.13
June	2.1	.105	.096	.000	.375	14.2	155	11.2	21.5	.04
July	2.2	.126	.041	.000	.825	14.2	170	12.8	33.6	.06
August	3.0	.190	.050	.000	.375	5.2	292	16.2	3.2	.06

Although, as has been stated, the sewage pollution of the Monongahela is more extensive near that city than in the Allegheny, it will be seen by comparison of Tables 83 and 88 that the Monongahela contains a smaller amount of organic matter than the Allegheny. The reason for this well illustrates what has already been said concerning the water of the Ohio Basin. The normal content of organic matter is so high that under ordinary circumstances the organic matter which is added to the river by the disposal of sewage therein does not increase the total amount to a significant degree. In other words, the amount of organic matter in the Ohio Basin is insignificant from the standpoint of sewage pollution, because of the fact that the unpolluted water often carries a larger amount of organic matter than the sewage brought into it. The two rivers under discussion well illustrate this point. We have in the Allegheny a "quick-spilling" basin, out of which is carried at times enormous amounts of sediment, consisting in a large measure of organic matter. The river flows swiftly, and there is little or no opportunity for sedimentation, so that when the water reaches Pittsburg its condition is not greatly improved nor changed.

In the Monongahela, on the other hand, we have a slack-water basin. Large amounts of silt are poured into it from the tributaries, as large as or larger than the amounts brought into the Allegheny. Yet because of the fact that there is ample opportunity in the slack water of the main river for subsidence, the water appears better upon chemical examination at Pittsburg in spite of the fact that comparatively large amounts of sewage are poured into the Monongahela only a short distance above. These facts illustrate excellently the point just enunciated; namely, that under ordinary circumstances the amount of organic matter emptied from sewers into the Ohio Basin

is small in comparison with that which is brought into the river from natural sources.

This consideration brings up the question of the value of determinations of organic matter in water, and seems to indicate that such determinations are of little aid in an investigation of this nature, if they are not indeed entirely useless. At all events, one should be very careful in regard to his premises before attempting to draw conclusions from determinations of organic matter.

MAHONING RIVER.

NATURAL RESOURCES.

Drainage area.—The area of the Ohio Basin next below the confluence of the Allegheny and the Monongahela rivers in which investigations have been made, the results of which have been published, is that of Mahoning River. This river drains 1,300 square miles in the eastern part of Ohio, being bounded on the north by the Lake Erie divide and on the south by the Muskingum and several other small streams, which enter the Ohio direct (see fig. 15).

The Mahoning rises in Columbiana County, Ohio, flows through the northeast corner of Stark County, and then by a circuitous course enters Portage, Trumbull, and Mahoning counties, flowing first in a northeasterly and then in a southeasterly direction, crossing the Ohio line and emptying into Beaver River in Pennsylvania, 8 miles from the Ohio boundary. Beaver River in turn enters the Ohio 40 miles below Pittsburg.

The basin of the Mahoning is rolling in some portions, while in others it is decidedly flat. It is rich in minerals and is extremely fertile. The valley is an important manufacturing place and is well supplied with transportation facilities. Under such favorable circumstances the population is rapidly increasing and the country is uncommonly prosperous.

Power.—The Mahoning is one of the best power streams in the Ohio Basin, and has been developed to an unusual extent as compared with other streams in this part of the country. Prof. Dwight Porter states that in the year 1880[a] 36 mills were situated upon the river, utilizing a total fall of 442½ feet, developing a horsepower of 1,146. It is probable that numerous changes have been made since that time in conformity with the decline of Ohio power values, and the figures are not applicable at the present date. The power developed is applied almost entirely to the grist and lumber business.

Flow.—There appear to be no satisfactory gagings of the flow of the river. In the report of the Ohio State Board of Health for 1898 there are given the results of a few measurements covering a period

[a] Tenth Census, vol. 17, pt. 2, p. 465.

of five months during a very dry season, but, as explained in that report, the gagings were attended by unfortunate circumstances which almost entirely vitiate their value, and they were not in any event continued for a sufficient period to indicate the normal flow of

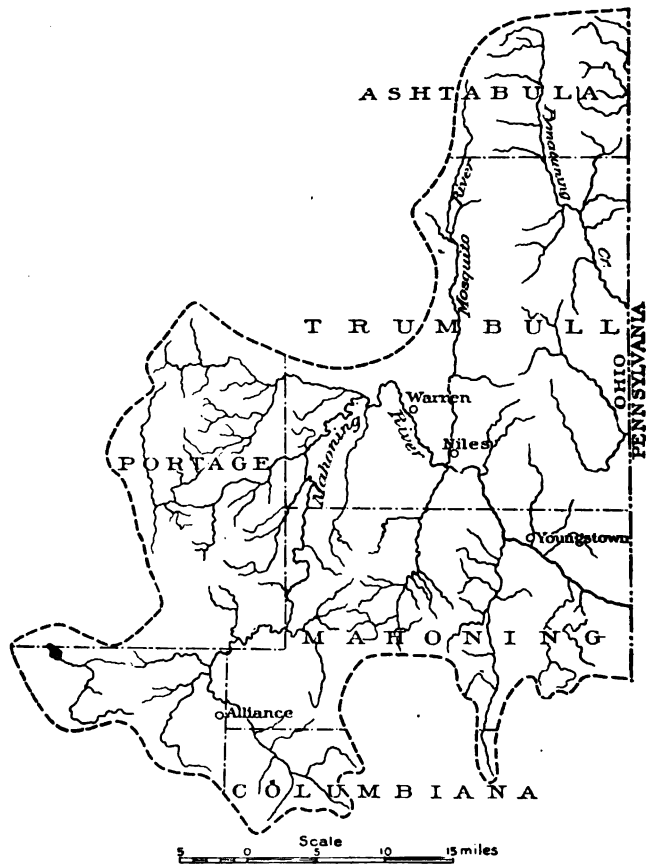

FIG. 15.—Mahoning River drainage basin.

the stream. The common observation is that the river fluctuates widely and is subject to freshets.

CHARACTER OF WATER.

No records of examinations of unpolluted water in the Mahoning Basin have been found. The excellent work of the State Board of Health was confined to districts undoubtedly polluted and therefore gives no idea of the character of the normal water in this basin. It is probable that the unpolluted surface water in the Mahoning Basin does not differ widely in character from that indicated by the analyses of the water of the river above Alliance, which will be shown below.

Alliance is a city of 8,974 inhabitants (census of 1900), and is situ-

ated in the upper part of the Mahoning Basin. Therefore it is the head of the extensive pollution for that basin. Above Alliance the drainage area comprises 73 square miles, and the population is not far from 60 per square mile. There are no mills nor factories on the river, and the country is largely devoted to manufacturing and dairying. There are six small villages on the river, the largest having probably no more than 300 inhabitants. Under some circumstances dangerous pollution might arise at two, North Georgetown and Damascus. Two miles above Alliance is situated the Fairmont Children's Home, which shelters about 200 persons, and pours raw sewage into the river. Under such circumstances when the water reaches the intake of the Alliance Waterworks it is generally in an acceptable condition, but is subject to the dangers above noted. The intake is well down toward the center of the city, so that there is undoubtedly a certain amount of contamination from Alliance itself.

TABLE 89.—*Analyses of water from Mahoning River above Alliance.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as-				Chlorine.	Total residue.	Hardness.	
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.
1897.										
June 19	None	4.5	0.528	0.136	0.012	0.23	1.5	240	110	36
July 24	Slight	7.0	.478	.126	.010	.28	.2	175	70	38
Sept. 2	Distinct	4.0	.390	.094	.005	.07	2.3	400	136	54
Sept. 29	None	1.5	.136	.059	.003	.00	3.0	415	182	58
Oct. 27	Very slight	2.0	.150	.060	.000	.00	3.2	410	204	54
Nov. 26	Decided	10.0	.592	.114	.007	6.5	2.3	470	78	64
Average			.379	.100	.006	.21	2.1	350	130	51

During the periods covered by the above table the rainfall at Akron, the nearest weather observation station, was as follows:

TABLE 90.—*Rainfall at Akron, Ohio.*

	June.	July.	August.	September.	October.	November.	Whole period.
Total fall	1.55	5.06	2.90	1.07	1.65	4.85	17.16
Variation	2.81	+1.20	.35	2.12	.77	+1.69	−3.16

The city of Alliance is provided with a system of water supply, and the consumption approaches 5,000,000,000 gallons daily. The sewer-

age system introduced in 1896 has been well extended, and in the year 1898 poured into the chemical precipitation works 300,000 gallons of sewage daily. The purification works do not seem to be extremely efficient, if we may judge from the analyses and bacteriological examinations made by the Ohio State Board of Health. The report of the bacteriologist in the year 1898 makes the following statement with reference to the Alliance sewage disposal:

At this town there is in operation sewage-disposal works which take care of the sewage by chemical precipitation. Examinations made at the works themselves showed that so far from this method destroying bacteria or lessening the number, the effluent from the works which discharged into the river was many times richer in bacteria than the original sewage, though the curve in general runs parallel with the curve above the station.

TABLE 91.—*Analyses of water from Mahoning River below Alliance.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.
1897.										
June 19	None	3.0	0.422	0.200	0.022	0.07	3.0	310	128	56
July 24	Slight	8.0	.520	.196	.020	.33	.2	165	56	34
Sept. 2	do	3.0	.422	.122	.015	.12	4.8	410	138	68
Sept. 29	None	2.0	.366	.473	.035	.....	9.0	415	170	68
Oct. 27	do	4.0	.356	2.100	.055	.03	15.5	480	216	98
Nov. 26	Decided	5.0	.390	.176	.022	.54	4.5	380	102	98
Average			.412	.544	.028	.18	6.2	358	135	70

The next important center of population below Alliance is Warren, in Trumbull County, which in 1900 had 8,529 inhabitants. The area of the watershed above Warren is not far from 600 miles, and the density of the rural population is about 45 per square mile. Between Alliance and Warren there are a large number of small country villages, having a population of 3,500 or 4,000, the most important being Newton Falls and Leavittsburg. At both of these places dangerous pollution may be expected, as well as from the Trumbull County Infirmary, which contributes a certain amount of sewage above the intake of the Warren waterworks. The river receives contamination from these three points, from Alliance, and from the storm sewers at Warren, which enter the river just above the waterworks.

TABLE 92.—*Analyses of water from Mahoning River above Warren.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.
1897.										
June 18	None	0.3	0.370	0.062	0.002	0.09	2.0	190	92	16
July 23	Decided	12.0	.606	.156	.010	.23	.3	130	36	22
Aug. 28	Very slight	3.0	.336	.062	.000	.....	3.5	245	100	28
Sept. 30	do	1.5	.180	.036	.005	.00	4.2	275	124	32
Oct. 28	Slight	3.0	.158	.018	.000	.00	3.7	235	140	14
Nov. 27	Decided	7.0	.440	.074	.009	.85	3.3	205	54	46
Average		3.0	.348	.068	.004	.20	2.8	213	91	26

In addition to this the industrial pullution is extensive. Within the city are situated numerous works, such as a rolling mill, tube works, and linseed-oil, flour, and paint mills, as well as a galvanizing plant, from which large quantities of waste acid are turned into the river.

TABLE 93.—*Analyses of water from the Mahoning River below Warren.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as-				Chlorine.	Total residue.	Hardness.	
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.
July 24	Decided	10.0	0.552	0.204	0.010	0.28	2.1	170	40	36
Aug. 28	Very slight	3.5	.430	.096	.004	.06	4.5	235	90	26
Sept. 30	do	1.5	.194	.070	.005	.00	8.7	275	126	18
Oct. 28	Slight	3.0	.304	.102	.017	.13	42.5	335	136	30
Nov. 27	Distinct	8.0	.454	.098	.017	.86	5.0	270	56	56
Average		5.2	.387	.114	.011	.27	12.6	257	90	33

The next important place on Mahoning River below Warren is Niles, which has a population or 7,468. Between Warren and Niles there is little pollution of a dangerous character, and the water which reaches the latter place is not materially different from that shown in Table 93. At Niles, although there is no complete system of sewers, the pollution is extensive and dangerous. There are probably about

50 house connections, with short lines of pipe; but in addition to these there are works which contribute waste, notably a tin-plate and iron-galvanizing plant, which discharge chemicals, mostly of an acid nature, into the river. During the summer of 1897 the river was discolored for 9 miles below Niles and many fish were killed. In addition to this the outhouses connected with the industrial plants are situated upon the edge of the stream, as is also that of a large schoolhouse. The pollution is therefore constant and dangerous, especially in view of the fact that this place is only about 10 miles above the intake of the Youngstown waterworks.

Analyses were made of water taken from the river below Niles, and a comparison of the results with those of analyses of water taken below Warren shows increased pollution. As will be noted by comparisons of Tables 93 and 94, the increase in chlorine is enormous. This, however, is not due entirely to sewage pollution, but arises from the influx of water from several salt springs in the vicinity of Niles.

TABLE 94.—*Analyses of water from Mahoning River below Niles.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.
1898.										
June 18		3.5	0.392	0.126	0.007	0.05	4.0	200	102	24
July 23	Decided	12.0	.620	.144	.010	.25	.3	135	34	18
Aug. 28	Slight	3.0	.328	.130	.005	.01	4.5	255	100	26
Sept. 30	None	2.0	.208	.078	.004	.00	4.5	245	124	12
Oct. 28	Slight	3.0	.268	.244	.001	.06	6.2	250	140	3
Nov. 27	Decided	10.0	.516	.096	.009	.88	3.3	233	54	42
Average		5.5	.389	.136	.008	.21	3.8	220	92	91

The next important center of population below Niles is Youngstown, the largest city on Mahoning River, containing 44,885 inhabitants. The area of the Mahoning Basin above Youngstown is approximately 900 miles, about 50 per cent of the population of which is urban. Between Niles and the water-supply intake at Youngstown the principal points are Cortland, Mineral Ridge, Canfield, Mahoning City Infirmary, Girard, Columbiana, and a part of the city of Youngstown itself, containing approximately nearly 10,000 persons. These represent a total population of 16,352.

The pollution from these centers is not extensive, and only that from the upper end of Youngstown may be termed dangerous. The

quality of water as it arrives at the Youngstown intake is therefore superior to that which leaves Niles.

TABLE 95.—*Analyses of water from Mahoning River above Youngstown.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.
1897.										
June 18	None	5.0	0.424	0.094	0.001	0.05	5.3	245	90	28
July 23	Decided	25.0	.716	.120	.005	.18	.3	145	22	20
Aug. 28	Very slight		.436	.112	.003	.07	4.0	200	56	24
Sept. 30	None	1.5	.192	.056	.004	Tr.	13.5	370	88	86
Oct. 28	do	3.0	.194	.052	.004	.04	15.2	380	106	60
Nov. 27	Distinct	20.0	.386	.096	.009	.46	5.0	255	64	54
Average		10.8	.391	.088	.004	.13	7.2	266	71	46

For some miles the Mahoning River flows through Youngstown. The city is provided with intercepting sewers, which carry all sewage below the water intake and discharge it into the river direct. After the addition of this sewage the water has the character shown in the following table.

TABLE 96.—*Analyses of water from Mahoning River below Youngstown.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.	
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.
1897.										
June 18	None	4.0	0.436	0.166	0.015	0.10	7.0	225	96	28
July 23	Decided	25.0	.908	.120	.010	.31	.5	220	26	38
Aug. 28	Very slight	8.5	.456	.218	.015	.27	6.5	215	64	28
Sept. 30	None	2.0	.268	.230	.030	.18	18.0	390	114	70
Oct. 28	do	5.0	.454	.750	.092	.27	25.2	405	130	78
Nov. 27	Distinct	20.0	.460	.150	.017	.56	5.7	283	52	58
Average		10.5	.497	.272	.030	.28	10.5	286	80	50

There are no analyses or public records applying to points below those indicated in Table 96; therefore the character of the contribution made by the Mahoning to the Ohio can not be determined. As has been stated, the Mahoning joins the Beaver a short distance below Youngstown, just east of the boundary line between Pennsylvania and Ohio. It is extremely probable that the Beaver is not polluted to the extent that the Mahoning is, and we may therefore be fairly certain that when the waters of the Mahoning reach the Ohio River their condition is greatly improved.

MUSKINGUM RIVER.

Drainage basin.—The drainage basin of the Muskingum is the largest in Ohio, covering 7,797 square miles. (See fig. 16.) It is formed at Coshocton by the confluence of the Walhonding and Tuscarawas, and from that point flows southward, then southeastward, a distance of 110 miles, entering the Ohio at Marietta. The other important tributaries are Licking River and Wills Creek.

The basin occupies nearly all of the southeastern part of the State, extending from Marietta up to the Lake Erie drainage divide, and from the Scioto Basin on the west to that of the Ohio River on the east. Geologically the basin is made up of two portions—a glaciated and an unglaciated area. The former includes, roughly, the western and northwestern parts of the basin; the latter comprises the remainder. Agriculture flourishes in the glaciated area, where the surface is smooth, rolling, or flat, while mining interests have been developed in the unglaciated part. Many parts of the basin are entirely deforested, yet some sections still bear timber.

Population of basin.—The population of the Muskingum Basin is large, and has been increasing at a rapid rate during the decade ending 1900. According to the Twelfth Census the total population is not far from 750,000, or about 97 per square mile. Of this, the urban population is approximately 200,000, leaving for the rural districts 550,000. These figures, while not exact, represent a careful estimate taken from the Twelfth Census reports.

WALHONDING CREEK.

The Walhonding has its origin in the west-central portion of Richland County. The highest section of the river is known as Black Fork; flowing southeastward it is joined by Rocky Fork and Jerome Fork, and below the confluence of the latter is known as Mohican River. Flowing still farther southeastward it is intercepted by Kokosing River, and from this point to Coshocton the term Walhonding Creek is applied to it.

BLACK FORK.

At the head of Black Fork the basin is a sparsely settled agricultural region, containing only four small hamlets, the largest having not more than 150 inhabitants. Shelby, a growing manufacturing town, having a population of 4,685, is the highest point of appreciable

FIG. 16.—Muskingum River drainage basin.

pollution. The run-off water from the area above this place is probably nearly normal.

The Ohio State Board of Health has made a faithful survey of the basin, and a series of chemical examinations was made during the spring, summer, and fall of the year 1899. In the published report of this work there appears a series of analyses of samples

of water taken from Black Fork above Shelby, which is reproduced below.

TABLE 97.—*Analyses of water from Black Fork above Shelby.*

[Parts per million.]

Date of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Precipitation, departure from normal for month.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1899.											*Inches.*
May 3	18	w[a]	0.166	0.071	0.008	0.06	4.1	406	197.6	33	−2.15
May 29	28	e	.660	.110	.002	.11	Tr.	956	120.8	13.9	.....
June 27	25	v	.174	.070	.002	.10	1.5	354	176.8	33.8	− .44
July 18	30	e	.268	.061	.016	.06	.9	407	153.6	84.8	+ .29
Aug. 17	20	v	.246	.088	Tr.	.02	4.3	428	191.6	81.6	2.21
Sept. 18	16	v	.166	.053	Tr.	.03	2.1	411	191.4	59.2	+1.31
Oct. 12	25	None.	.146	.033	Tr.	.00	1.3	414	227.4	48.2	− .06
Nov. 17	45	e	.132	.018	.004	.02	1.7	468	181.8	98.6	−1.62
Average.	26	.....	.245	.063	.004	.05	2.0	480	180.1	56.6	.....

[a] w, woody; e, earthy; v, vegetable.

The results above reported indicate that the water analyzed contained considerable organic matter, which, if we may judge from the conditions existing in the contributing drainage area, is of vegetable origin. The water is not highly colored and there is no indication that pollution exists other than that inevitably arising from decayed vegetation. The free ammonia, nitrites, and chlorine are low; the water contains a comparatively large proportion of alkaline salts, which cause a high degree of hardness. It is evident, however, that nearly 75 per cent of these salts are carbonates. In general, the series of analyses is important because it is one of a very few available reports upon a normal or practically normal surface water in the northern drainage basin of the Ohio River.

For purposes of comparison, analyses of water from Black Fork below Shelby were made by the State Board of Health, the samples being collected at the same time as were those reported in Table 97.

TABLE 98.—*Analyses of water from Black Fork below Shelby.*

[Parts per million.]

Date of collection.	Color.	Odor.	Nitrogen as—			Chlorine.	Total residue.	Hardness.		Precipitation, departure from normal for month.
			Albuminoid ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1897.										*Inches.*
May 3	12	d[a]	0.238	0.015	0.06	11.7	538	115.8	100.9	2.15
May 29	32	e	.530	.032	.15	7.8	435	103.0	54.1	.....
June 27	17	d	.198	.034	.12	12.5	473	137.8	87.0	.44
July 18	60	v	.352	.022	1.25	6.3	383	110.2	88.8	.29
Aug. 17	20	v	.236	Tr.	.05	28.3	810	57.2	327.6	2.21
Sept. 18	20	Cattle	.442	.002	.06	32.1	959	90.4	350.6	1.31
Oct. 12[b]	----	----	----	----	----	----	----	----	----	0.06
Nov. 17	20	m	.100	.014	.06	8.7	598	77.4	225.6	1.62
Average.	26	.....	.299	.017	.25	15.3	599	98.8	176.4	.....

[a] d, disagreeable; e, earthy; v, vegetable; m, moldy. [b] No water flowing.

The effect of pollution from Shelby is evident in the analyses above reported. There is a significant rise in the proportions of free ammonia, nitrites, and chlorine, which can be due to nothing else than sewage pollution. It is worthy of note that there is a great change in the character of the alkaline salts contained in the water. The marked decrease in alkalinity, accompanied by the increase in normal hardness, shows that through some influence, probably by the discharge of some chemical at Shelby, the carbonates have been changed to sulphates or chlorides.

Black Fork is joined by Rocky Fork about 30 miles below Shelby, but the intervening country is sparcely settled and there is little further material pollution except that from Richmond County Infirmary.

ROCKY FORK.

The drainage area of Rocky Fork lies in the central part of Richland County, immediately south of that of Black Fork. During past years it has been one of the most grossly polluted streams in Ohio, because of the discharge into it of raw sewage from Mansfield, a city of 17,640 inhabitants. The condition of the stream below this city has been so offensive that it became necessary to establish a system of sewage disposal. The Ohio State Board of Health examined, previous to the installation of this disposal plant, two series of samples of water from Rocky Fork, one of the sampling points being located

above the city and the other below. That part of the drainage area above Mansfield comprises a country richly fertilized for agricultural purposes, and the run-off is therefore not normal for the basin.

TABLE 99.—*Averages of analyses of water from Rocky Fork, above and below Mansfield.*

[Parts per million.]

Place of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Number of analyses made.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
Above Mansfield	20		0.282	0.051	0.005	0.08	2.9	512	169.7	59.0	8
Below Mansfield	23	f[a]	.413	.088	.088	.14	16.7	583	146.1	55.5	8

[a] f, fishy.

It is hardly necessary to comment on the contrast offered by the two averages set forth in the above table. The second statement shows an enormous increase in organic matter, in chlorine, and in all other constituents which serve to indicate extensive sewage pollution. It is believed that the river has been improved since the establishment of the Mansfield sewage purification works, but an analytical proof is not at hand.

Between the junction of Rocky Fork and Black Fork and the entrance of Clear Fork is the village of Loudensville, containing 1,500 inhabitants. There is no public water supply or sewerage system, but there is nevertheless considerable drainage into the stream by private sewers, ditches, and gutters.

Clear Fork appears to be a comparatively clean stream, the principal center of population within its drainage area being Belmont, which has a population of 1,039.

JEROME FORK.

At the confluence of Black and Jerome forks is the head of Mohican River. Jerome Fork drains the greater part of Ashland County and the western portion of Wayne County. The only place of importance upon the stream is the city of Ashland, with 4,087 inhabitants, provided with a water supply and sewerage system.

MOHICAN RIVER.

From the above statements, it is clear that the water contributed to Mohican River by the tributaries described is badly polluted and of little value in its raw state as a water supply. The remainder of

the resources vested in the water of this stream are probably not greatly affected by pollution.

OWL CREEK.

Mohican River flows nearly due south to its confluence with Owl Creek, and there are upon its banks no important centers of population. The water flowing in the channel must, therefore, constantly improve in quality. Owl Creek, however, is a different stream; it drains the greater part of Knox County, and extends to the Scioto River divide. The country is level and is a very fertile agricultural region. In the middle of the drainage area is the city of Mount Vernon, having a population of 6,633. It is a rather important manufacturing town, although it has not grown much during the last decade. A water supply and a system of sewerage has been provided, the latter emptying directly into Owl Creek. There is also considerable surface pollution from vaults and cesspools. Above the city of Mount Vernon there are, in Owl Creek Basin, several small villages, which, together with the richly fertilized fields, contribute a sufficient amount of pollution to the river to materially change the quality of the water, which would otherwise be normal.

TABLE 100.—*Averages of analyses of water from Owl Creek above and below Mount Vernon.*

[Parts per million.]

Place of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Number of analyses made.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
Above Mount Vernon	13	o[a]	0.095	0.036	0.003	0.05	1.2	292	192.0	13.9	8
Below Mount Vernon	14	M	.121	.060	.009	.08	3.1	303	190.7	33.3	8

[a] o, oily; M, musty.

KILLBUCK CREEK.

Killbuck Creek enters Mohican River a short distance below the mouth of Owl Creek. It drains a large part of Wayne and Holmes counties and a small part of Coshocton County. At the headwaters of this stream is a comparatively large rural population, the principal centers of which are Warsaw and Creston, while the highest town of importance is Wooster, a city of 6,063 inhabitants.

Above Wooster two points were selected by the Ohio State Board of Health for the collection of samples of water for analysis; one in Killbuck Creek, above the mouth of Apple Creek, which flows in at Wooster; one in Apple Creek above Wooster, and the third below Wooster,

the latter representing a mixture of waters from both Killbuck and Apple creeks. Above Wooster on Apple Creek are the Wayne County Childrens' Home and the Wayne County Infirmary, which pollute the water of the stream to some extent. At Wooster are Wayne College and several industrial establishments.

TABLE 101.—*Averages of analyses of water from Apple and Killbuck creeks above Wooster and from Killbuck Creek below Wooster.*

[Parts per million.]

Place of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Number of analyses made.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
Killbuck Creek above Wooster	28	M[a]	0.336	0.112	0.006	0.05	5.4	336	130.1	23.4	8
Apple Creek above Wooster	19	None.	.153	.038	.003	.05	2.6	254	140.2	16.6	8
Killbuck Creek below Wooster	28	M	.322	.165	.022	.09	6.5	359	130.5	28.3	8

[a] M, musty.

Between Wooster and the junction of Killbuck Creek with Walhonding Creek there are numerous small villages, a few being provided with small sewerage systems. It is more than likely that the condition of the water shown in the last analysis in Table 101 is maintained by these small pollution points in practically the same condition as that indicated in the table.

From the mouth of Killbuck Creek it is only a short distance down Walhonding Creek to Coshocton, the head of Muskingum River. The Ohio State Board of Health has made an analysis of the water of Walhonding Creek above Coshocton which shows clearly the character of the water contributed to the Muskingum by the Walhonding Basin.

TUSCARAWAS RIVER.

The basin of the Tuscarawas covers about 2,547 square miles in the northwestern portion of Muskingum watershed. It is the largest tributary of the Muskingum, flowing through a fertile, prosperous country, which has a large population, and is dotted over with rapidly growing municipalities. In the central-southeastern part of the basin coal mining is largely developed, while agriculture is confined in general to the northern and western portions. The river rises in Summit County, and, by a somewhat circuitous route, finally takes a course southwest, flowing through Stark, Tuscarawas, and Coshocton counties, and meets Walhonding Creek at Coshocton to form the Muskingum.

The tributaries of the Tuscarawas are important, and cover diversified portions of the drainage area. Chief among these is Big Stillwater Creek, which flows from the south, through Harrison and Tuscarawas counties, draining an area of 472 square miles. Sugar Creek flows in from the northwest, its basin comprising 356 square miles. Sandy Creek is an important stream which flows in from the east, along the northern part of Carroll and the southern boundary of Stark counties.

HIGHLAND TRIBUTARIES.

Wolfe and Chippewa creeks drain the northernmost portions of the Tuscarawas Basin, comprising parts of Summit, Medina, and Wayne counties. There are numerous small villages in the basin, which have no important influence on the character of the run-off water, although they undoubtedly pollute it to some extent. The first important center of population is Barberton, a comparatively new town, the growth of which has been rapid, by reason of the recent establishment of manufacturing. A system of sewers has been provided, which serves about 3,000 people, and has an outlet in Wolfe Creek. The manufacturing refuse, too, damages the stream to some extent. Wadsworth, Orrville, Dalton, and Doyleston are situated in the drainage area. These municipalities are not important, although from Wadsworth there is considerable contamination of the stream from the salt works established there. Rillman is also an important center of the salt industry, the wastes from which impregnate the whole drainage from this section.

The largest city in the Tuscarawas Basin is Massillon, an important manufacturing place in Stark County, situated a few miles below the confluence of Wolfe and Chippewa creeks, and having a population of 11,944. Refuse from strawboard factories and other manufacturing plants, as well as the sewage from a combined system of sewers, pollutes the stream. The Ohio State Board of Health has made a series of analyses of the water taken from the river above and below Massillon, the average results of which are set forth in Table 102.

TABLE 102.—*Averages of analyses of water of Tuscarawas River above and below Masillon.*

[Parts per million.]

Place of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Number of analyses made.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
Above Massillon	23	v[a]	0.175	0.060	0.003	0.06	102.8	513	136.8	58.8	8
Below Massillon	29	M	.343	.093	.007	.10	64.5	578	152.0	33.6	8

[a] v, vegetable; M, musty.

In the above analyses the effects of waste from salt works are readily apparent in the high chlorine content. Aside from this, the river shows a high content of organic matter, which, although no records of normal water are available for comparison, seems to indicate pollution from the country above. The average representative analyses of water from the river below Massillon show a characteristic increase in the amount of organic matter, yet the chlorine does not appear to be present in so large proportion as above the city. This is not explained in the last report of the Ohio State Board of Health; it may be due to dilution, as there are two streams entering the river between the sampling point above the city and that below.

SANDY CREEK.

Sandy Creek enters the Tuscarawas a short distance below Massillon, and contributes a considerable amount of pollution from Canton, Wellsville, Minerva, and other small places. Minerva has a population of 1,200 and is situated upon Clear Fork, at the extreme eastern end of the Muskingum Basin.

NIMISHILLEN CREEK.

The principal stream of interest in the Sandy Creek drainage area is a tributary called Nimishillen Creek, which drains the country to the north, including the city of Canton and the village of Louisville. The latter is situated upon the east branch of the creek, has a population of 1,374, and is provided with a public water supply, but no sewers. The east branch runs through Canton and joins the west branch at the lower end of the city. The Ohio State Board of Health has conducted two series of analyses of water from west branch, one above and one below Canton.

TABLE 103.—*Averages of analyses of water from Nimishillen Creek above and below Canton.*

[Parts per million.]

Place of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.	Number of analyses made.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
Above Canton	28	23	v[a]	0.176	0.051	0.006	0.35	2.0	284	150.6	35.1	2,400	8
Below Canton	70	28	M	.446	.741	.089	.30	10.4	843	151.7	50.2	95,000	8

[a] v, vegetable; M, musty.

The contrast presented by the above averages indicates unmistakably the great change in the character of the water after it receives pollution from Canton.

TUSCARAWAS AT CANAL DOVER AND NEW PHILADELPHIA.

Canal Dover and New Philadelphia are cities situated on the opposite sides of Tuscarawas River at the junction of Sugar Creek, a stream which drains a considerable area of country to the northwest. The former city has a population of 5,422; the latter contains 6,213 inhabitants. Both are important manufacturing places, and their industrial plants contribute a large amount of foul matter to the river. Canal Dover has no sewerage system at present, but the drainage into the river is nevertheless extensive. New Philadelphia has an excellent sewerage system, which discharges into the river. We have, then, at this point a combined population of 11,635, the wastes from which have an important effect on the quality of the Tuscarawas River.

TABLE 104.—*Averages of analyses of water from Tuscarawas River above Canal Dover and below New Philadelphia.*

[Parts per million.]

Place of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Number of analyses.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
Above Canal Dover	23	e[a]	0.227	0.062	0.005	0.07	23.9	369	112.8	39.3	8
Below New Philadelphia	24	e[a]	.237	.060	.005	.10	23.4	343	107.4	36.2	8

[a] e, earthy.

Comparison of the results of analyses from the two points above stated shows that the water in Tuscarawas River is not materially changed after receiving the pollution from Canal Dover and New Philadelphia. It is probable that the amounts of nitrogen and of chlorine are practically the same, and that the color, turbidity, and odor do not differ widely. The reason for this is not far to seek. Examination of the map will show that between the sampling point above Canal Dover and that below New Philadelphia three tributaries enter—Sugar Creek, Stone Creek, and Oldtown Creek. The first of these tributaries drains an area of 356 square miles; the other two have basins considerably smaller. The water flowing from these tributaries is not polluted to any significant extent, and it is reasonable to believe that the large measure of dilution, which must, of necessity, arise, is sufficient to account for the lack of material difference in the character of the water as shown by analyses at the two sampling

points. The quantitative determinations of bacteria made by the State Board of Health, however, tell another story. It has also been remarked that the differences between gelatin culture media manufactured in different laboratories are often the cause of varying results in determining the number of bacteria, so that when the same water is tested the number of bacteria found in different cases varies widely. Therefore little value can be given to quantitative determinations, unless numbers vary to such an extent that the difference between one and the other is greater than any possible error introduced by the discrepancy in the work. In the report of the Ohio State Board of Health, above referred to, the average number of bacteria per cubic centimeter above Canal Dover is 2,350, and below New Philadelphia 6,200, a difference so wide that it can not be reasonably accounted for by variations which might be introduced into the work by the use of nonuniform culture media. The media used in these determinations were all made in the same laboratory and, presumably, after the same methods, so that it is probable that the above-described variation would not occur. The fact that there are so many more bacteria in the water below New Philadelphia than above Canal Dover arises unquestionably from the difference in the character of the organic matter. In other words, the fact that there is sufficient organic matter of a certain kind in the water at the lower sampling station to provide food for 6,200 bacteria, while at the upper station it is suffi ient in amount to provide food for only 2,350, shows that the character of the organic matter has been seriously changed, even though the large degree of dilution arising from the cause above stated preserves the proportionate amounts practically the same.

STILLWATER CREEK.

After proceeding down Tuscarawas River for 5 or 6 miles one comes upon the confluence of Stillwater Creek. This stream has a drainage area of 472 square miles, lying principally in Harrison, Belmont and Tuscarawas counties. The river forks a few miles from this confluence with the Tuscarawas, and thereafter the northernmost branch is called Little Stillwater Creek, while that immediately to the south is known as Big Stillwater Creek. The pollution in the basin of Little Stillwater Creek is not extensive, while in the upper part of the Big Stillwater Basin there are only a few small centers of population, such as Barnesville, Piedmont, and Freeport. At the junction of the two forks are situated the municipalities of Uhrichsville and Dennison.

The following statement of averages of analyses of water above Uhrichsville and below Dennison are taken from the report of the Ohio State Board of Health, above referred to.

TABLE 105.—*Averages of analyses of water from Stillwater Creek above Uhrichsville and below Uhrichsville and Dennison.*

[Parts per million.]

Place of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Number of analyses made.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
Above Uhrichsville	25	M[a]	0.287	0.089	0.007	0.07	4.5	344	114.1	17.8	8
Below Uhrichsville and Dennison	25	M	.288	.188	.007	.17	7.1	376	98.8	40.2	8

[a] M, musty.

The evidences of increase in pollution appearing in the two averages above referred to are easily appreciable, notably by the rise in free ammonia and chlorine.

Below the mouth of Stillwater Creek, in the course of the 40 miles which intervene between that point and the head of Muskingum River, small villages are situated upon the banks of the stream, containing the usual number of industries, but the only important center of pollution is Newcomerstown, which has, according to the Twelfth Census report, 2,659 inhabitants.

MUSKINGUM RIVER BELOW COSHOCTON.

Walhonding Creek and Tuscarawas River are further polluted at their confluence by drainage from the city of Coshocton, which has a population of 6,473. Along the water front of this city are located important manufacturing plants, which pour their wastes into the stream. The city is provided with a water supply and sewerage system, and the sewage, together with that carried by surface drains, as well as the town garbage, is poured into the river. There arises, therefore, at this point an important contamination, which is said to be offensive during periods of low water. Three series of analyses have been carried on at Coshocton by the Ohio State Board of Health. The sampling points chosen were Walhonding Creek and Tuscarawas River, both above the confluence of Coshocton pollution, and a point on Muskingum River at a proper distance below the confluence of the two main tributaries where it was reasonably certain that the waters of the two streams and the pollution from Coshocton were thoroughly mixed.

TABLE 106.—*Averages of analyses of water from Walhonding Creek and Tuscarawas River above Coshocton and from Muskingum River below Coshocton.*

[Parts per million.]

Place of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Number of analyses made.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
Walhonding Creek above Coshocton	.....	21	e[a]	0.187	0.045	0.004	0.10	5.4	308	139.0	14.4	8
Tuscarawas River above Coshocton	.....	16	....	.128	.028	.003	.05	20.6	303	119.0	29.1	8
Muskingum River below Coshocton	113	20	....	.180	.043	.005	.05	19.4	329	130.4	49.2	8

[a] e, earthy.

Comparison of the analyses of water from Walhonding Creek above Coshocton with those of water from Tuscarawas River shows that the latter is not so highly colored. The amount of residue is the same as in the Tuscarawas, the alkalinity higher, but the normal hardness less. It is notable that the content of chlorine in the Tuscarawas is higher, the difference being due principally to contamination from the salt works in the upper part of the basin of that tributary. The Walhonding has more organic matter than the Tuscarawas. In both streams the water is greatly damaged by pollution, but the nuisance occasioned thereby is not general, being confined to certain localities near points of discharge of certain city sewers.

WILLS CREEK.

Wills Creek enters the Muskingum from the east a short distance below Coshocton. It is the drainage outlet of Guernsey County, and the basin comprises also small areas in Noble and Belmont counties. The creek is formed by the confluence of Buffalo Fork and Seneca Falls Creek a short distance north of Noble County line, and pursues an extremely winding course to its outlet, running through Guernsey, Coshocton, and Muskingum counties and into the Muskingum River. The only considerable center of population in the drainage area is Cambridge, a city of 8,241 inhabitants. This is an important coal-distributing point, and it contains tin and iron mills, which contribute considerable amounts of wastes to the river. Sewers have been introduced at Cambridge and, although they have not been widely extended, they do their full measure of damage to the stream. Leatherwood Creek, which enters Wills Creek at Cambridge, drains an important mining district and, as a result, is very turbid by reason of a large amount of coal-mine waste.

The Ohio State Board of Health has conducted a series of analyses of water above and below Cambridge on Wills Creek. That above Cambridge is not representative of the character of Leatherwood Creek water.

TABLE 107.—*Averages of analyses of water from Wills Creek above and below Cambridge.*

[Parts per million.]

Place of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Number of analyses made.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
Above Cambridge	784	23	v[a]	0.227	0.109	0.017	0.12	26.6	474	136.8	40.7	8
Below Cambridge	464	24	M	.295	.204	.025	.14	10.0	352	92.5	65.6	8

[a] v, vegetable; M, musty.

The results above set forth indicate a considerable rise in free ammonia, nitrites, and chlorine after the water passes Cambridge. Mr. Benjamin H. Flynn, engineer of the Ohio State Board of Health, is of the opinion that there is not sufficient discharge of sewage from Cambridge to account for so great a rise in the constituents indicating sewage pollution, and that the change is probably due to industrial wastes. The reduction in the amount of turbidity is interesting, as it indicates a possible discharge of coagulating material from the mines, probably sulphate of iron. To this extent, therefore, the industrial pollution may be regarded as a benefit.

LICKING CREEK.

About 20 miles below the confluence of Wills Creek is the city of Zanesville, at which point Licking Creek joins the Muskingum. This stream drains the north of Licking County and part of Knox, Perry, and Muskingum counties. The western part of this basin is level and is devoted to agriculture, while the eastern part is hilly. At the headwaters of the stream are many small towns, the principal ones being Centerburg, Utica, Pataskola, Johnstown, and Granville, having a combined population of 4,270.

Newark, with a population of 18,157, is the commercial center of the basin. It contains many manufacturing industries and several slaughter houses, and these, together with the city sewage, make the river very foul at times.

Analyses of water from Licking Creek above Newark indicate that it is rich in organic matter, yet there is no special evidence of dangerous contamination, while the samples taken from the stream below Newark present the usual contrast.

TABLE 108.—*Averages of analyses of water from Licking Creek above and below Newark.*

[Parts per million.]

Place of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.	Number of analyses made.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
Above Newark..	87	13	None.	0.106	0.029	0.002	0.04	1.6	309	184.0	21.3	700	8
Below Newark..	99	14	M[a]	.162	.088	.006	.07	3.0	329	181.4	13.4	5,200	8

[a] M, musty.

The city of Zanesville, with population of 23,538, is the largest center of pollution yet considered in the drainage basin of the Muskingum. The water supply is taken from Muskingum River just above the city, but the water is so impure that steps are now being taken to improve its quality or to procure another source of supply. A sewerage system has been provided, and the manufacturing industries are important. In addition to the contamination from sewers and from these manufacturing plants, the river receives sewerage drainage, which is dangerously polluted by slovenly methods of disposing of garbage and night soil.

The Ohio State Board of Health has conducted three series of examinations, eight samples being taken from each of the following points: Muskingum River above Zanesville, Licking Creek above Zanesville, and Muskingum River below Zanesville. The averages of the results of these examinations are reproduced below.

TABLE 109.—*Average results of analyses of water from Licking Creek above Zanesvile and from Muskingum River above and below Zanesville.*

[Parts per million.]

Place of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.	Number of analyses.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
Licking Creek above Zanesville	15	0.288	0.059	0.006	0.05	3.2	510	165.3	21.4	2,700	8
Muskingum River above Zanesville	25	.285	.063	.006	.08	10.0	498	114.2	35.9	2,700	8
Muskingum River below Zanesville	24	.324	.088	.009	.08	9.6	530	118.7	23.4	12,000	8

There is a striking similarity in the analyses of the waters from Muskingum River and from Licking Creek above Zanesville. In fact,

the determinations practically conform, the only significant departure being in the case of chlorine. In the preceding pages it has been noted that salt works contributed large quantities of waste to the Tuscarawas River, which results in raising the amount of chlorine to a height unwarranted by existing sewage pollution. To this is probably due a part of the excess of chlorine in water in Muskingum River above Zanesville over that in Licking Creek.

In the introduction to this paper it was stated that the chlorine contributed to surface water does not undergo mechanical change similar to that which takes place in the nitrogen compounds, but firmly maintains its identity, fluctuating in amount according to the dilution which it receives from tributaries, or the contributions from sewers and other polluting factors, and when organic matter is completely changed to inorganic compounds, and all other trace of contamination is lost, the chlorine remains an unshaken witness of past pollution. We have also seen in the pages immediately preceding that large amounts of sewage are poured into the streams in the Muskingum Basin. By the time the water reaches Zanesville the organic matter poured in from the cities in the upper part of the basin has been nearly or completely consumed, and that which appears on analysis is undoubtedly of recent origin. But the chlorine in the Muskingum, which is in so great excess over that in Licking Creek, is largely the evidence of pollution both from sewage and from the salt works in the upper part of the basin.

The condition of the water of Licking Creek is so similar to that of Muskingum that it can not be said that either stream is a detriment or a benefit to the other. In the one case we have a water recently polluted, while in the other it appears that the water was at one time more seriously contaminated, but through the effects of oxidation, sedimentation, and dilution the evidences of this contamination have been nearly lost, and the most apparent pollution is that derived from sources not far above Zanesville.

Analyses of the water of the Muskingum below Zanesville show, in a fairly satisfactory manner, the effect of the commingling of the waters of Licking Creek and Muskingum River in conjunction with the wastes of Zanesville.

Below Zanesville, on the Muskingum and on the minor tributaries, there are a number of small towns which, while collectively they contribute some foreign matter, do not influence the character of the water extensively. There is no place of importance until McConnelsville is reached, the county seat of Morgan County, containing 1,825 inhabitants, and provided with water supply and sewers. Just above this place the Ohio State Board of Health has taken a series of samples for examination, the results of which are embraced in the following table.

TABLE 110.—*Analyses of water from Muskingum River above McConnelsville.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c.c.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1899.												
April 28	35	10	None.	0.178	0.088	0.004	0.08	5.8	269	101.1	56.8	350
May 24	271	28	e[a]	.234	.090	.007	.08	3.8	304	73.0	50.0	1,400
June 22	(b)	20	e	1.064	.152	.003	.13	2.1	1,784	44.5	7.6	7,000
July 25	206	.....	v	.230	.058	.009	.26	11.8	296	90.8	21.8	1,400
August 30	114	22	v	.228	.156	.018	.04	14.8	329	147.2	40.0	1,400
September 27	65	20	e	.164	.046	.012	.10	14.3	306	152.2	None.	420
October 17	52	10	v, e	.140	.028	.015	.06	15.7	308	152.2	31.8	370
November 22	52	20	None.	.162	.034	.004	.11	19.0	315	142.2	49.0	420
Average	.....	19	.....	.300	.075	.009	.11	10.9	489	112.9	32.1	1,600

[a] e, earthy; v, vegetable. [b] Enormous.

From McConnelsville to Marietta, at the mouth of the river, there are the usual number of small villages, the effects of which upon the character of the water are not important. Marietta, with population of 13,384, has considerable manufacturing and a public water supply and sewerage system, which empties into Ohio River, so that it has no effect on the Muskingum. There is, however, considerable manufacturing sewage poured into the latter.

TABLE 111.—*Analyses of water from Muskingum River above Marietta.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c.c.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1899.												
April 28	52	10	p[a]	0.102	0.056	0.002	0.10	5.7	275	112.4	57.9	350
May 24	600	25	e	.216	.046	.009	.09	2.9	396	71.8	22.4	550
June 22	(b)	22	e	.464	.136	.004	.12	9.3	1,017	93.9	52.0	3,900
July 25	210	28	v	.296	.066	.008	.05	8.2	294	93.6	17.0	600
August 30	80	20	e	.202	.052	.012	.04	8.9	245	122.2	55.0	170
September 27	80	25	e	.158	.022	.010	.05	18.5	304	143.6	6.4	300
October 17	110	10	m	.120	.016	.008	.03	11.2	300	146.8	62.0	275
November 22	49	10	None.	.112	.016	.004	.16	17.9	322	144.2	39.4	1,700
Average	.....	19	.....	.209	.050	.007	.08	9.7	380	116.1	39.0	1,000

[a] p, peaty; e, earthy; v, vegetable; m, moldy. [b] Enormous.

The above analyses show fairly well the character of the water contributed to the Ohio system from the Muskingum Basin. The water

improves in quality between Zanesville and the mouth of the river, and therefore the effect of the Muskingum system on the Ohio is less damaging than might be supposed after considering the points of pollution in the Muskingum.

The analyses given certainly show that the Muskingum is in many places a very foul stream. Indeed, there are few points at which water can be collected in its normal and undamaged state. This stream is certainly not a proper one to use as a sewage course, for its greatest value is in its water resources. It is not good for much as a source of power, its navigation is insignificant, and the humid climate of the country makes its use for irrigation unnecessary. There are, perhaps, certain points along the course of the stream which are fit places for the harvesting of an ice crop, but the Muskingum can never be an extensive ice field. Therefore the water-supply value of the river is practically the only important one, and, as has been shown, this is greatly damaged. It is unwise to utilize for domestic purposes the waters of the Muskingum and its tributaries at almost any point unless efficient means of purification are adopted. On the other hand, the character of the river basin is such that self-purification readily takes place. There is no doubt that if means were used to purify the sewage which is now poured into the stream, the waters could, in certain places, be used as a water supply without any treatment.

SCIOTO RIVER.

DRAINAGE BASIN.

The drainage basin of Scioto River occupies a long, narrow strip of country in the central and southern part of Ohio, extending from the Lake Erie drainage divide on the north to the Ohio River at Portsmouth on the south, and comprising about 6,400 square miles. The source of the river is in Auglaize County, in a portion of the drainage area which juts westward and lies north of the Great Miami Basin. Thence it runs in a generally southerly direction 40 miles, to a point a little southwest of the city of Marion. The fall along this section is nearly 500 feet. Thence its course is almost due south. It passes through the city of Columbus, capital of the State of Ohio, the fall from Marion to this point being 430 feet. Continuing south, the river joins the Ohio at Portsmouth, 110 miles above Cincinnati. The fall of the river between Columbus and Portsmouth averages 26 feet per mile along the entire length of 130 miles. The entire course of the river, measured in a straight line, is 175 miles, although when actually traversed it amounts to nearly 210 miles.

The tributaries are not so large nor so important in this drainage area as they are in the Muskingum, by reason of the fact that the watershed is somewhat narrow. The most important tributaries and the area drained by them are named below.

TABLE 112.—*Drainage area of Scioto River and tributaries.*

	Sq. miles.
Olentangy River at mouth at Columbus	547
Big Walnut Creek at mouth	513
Darby Creek at mouth	592
North Fork of Paint Creek	236
Main Fork of Paint Creek above junction with North Fork	828
Paint Creek at mouth	1,083
Scioto River at southern boundary of Marion County	628
Scioto River at Columbus, above junction with Olentangy River	1,139
Scioto River at Columbus, below junction with Olentangy River	1,686
Scioto River at Circleville and Darby creeks	3,275
Scioto River at Chillicothe	3,923
Scioto River at mouth	6,400

The principal economic value of Scioto River lies in its availability as a source of water supply. It is not an important power stream, although in past years the aggregate of power developed by the numerous plants along it was fairly large, but on account of the flatness of the area there is not sufficient opportunity to develop many or extensive power sites, those which have been utilized being of the capacity which are found necessary to the development of saw and grist mills only. The development of cheaper power in other parts of the country and the improvement of transportation facilities have led to the abandonment of a large number of the power privileges afforded by the Scioto, and very few of those that remain are of much value. Even as a source of water supply the opportunities for conservation are not all that could be desired, for it is necessary in some places to pump the water directly from the flowing stream into distributing reservoirs, the storage capacity of which is not in every case sufficient to allow the water to be properly stored and purified. This condition aggravates the dangers due to polluted river water, for under these circumstances pollution becomes more certain in its unfavorable effects upon the water consumer than it could be if a longer term of storage were afforded.

NORMAL WATER IN THE SCIOTO BASIN.

There are no public records of analyses of a distinctively normal water in the Scioto Basin. The work of the Ohio State Board of Health has so far been confined almost entirely to the examination of polluted streams, and it is only from the series of analyses made near the headwaters of the rivers and above the highest points of appreciable sewage pollution that we are able to obtain any ideas concerning the character of these waters in their normal state. In the basin of the Scioto it is probable that the analysis affording the best idea of the character of its normal water is that which has been made of samples collected above the city of Kenton, in Harding County. The population above the city is almost entirely rural, there being a few small villages, containing from 25 to 100 inhabitants, and while the

contamination which they impart to the headwaters of the Scioto is hardly appreciable, yet it can not be said that the water which reaches Kenton is normal. It is probably nearly so, and for all practical purposes can be so considered. The analyses of this water appear in the following table:

TABLE 113.—*Analyses of water from the Scioto River above Kenton.*

[Parts per million.]

Date of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1898.											
June 12	4	None.	0.514	0.062	0.024	1.50	2.0	730	210	226	1,300
July 16	4	e[a]	.462	.098	.003	.42	1.0	805	232	.....	480
August 25	2	None.	.292	.084	.000	.00	2.5	625	234	130	430
September 25	4	e	.238	.028	.000	.00	3.8	670	226	122	270
October 23	3	M	.240	.030	.000	.00	3.3	605	252	112	390
December 1	5	M	.638	.571	.030	9.38	1.5	1,075	104	510	1,900
Average	4	.....	.379	.145	.010	1.900	2.3	752	210	183	790

[a] e, earthy; M, musty.

POLLUTION IN BASIN OF THE SCIOTO.

Kenton is a city of 6,852 inhabitants, provided with sanitary sewers and storm-water drains. Both systems discharge into the river. The effect upon the water is easily appreciable upon examination of the following table:

TABLE 114.—*Analyses of water from the Scioto River below Kenton.*

[Parts per million.]

Date of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1898.										
June 12	4.5	0.430	0.142	0.026	1.60	4.0	710	214	228	.....
July 16	3.0	1.720	.476	.000	.00	4.5	720	32	.....	5,800
August 25	2.0	1.328	.384	.010	.00	6.5	605	232	118	2,400
September 25	3.5	.360	.764	.003	.00	12.5	645	238	114	4,200
October 23	3.0	.588	2.160	.005	.00	18.0	650	258	114	17,000
December 1	5.0	.624	.584	.030	.44	2.0	975	118	466	14,000
Average	3.5	.841	.751	.012	.....	7.9	718	182	173	8,700

Continuing down the Scioto no further important source of pollution is met with until the mouth of Little Scioto River is reached. In the drainage area of this river is the city of Marion, containing, according to the Twelfth Census, 11,862 inhabitants. Sewer outlets enter the river a short distance above its confluence with the Scioto, and there are published records of analyses of the water from Little Scioto, above and below the sewer outfall, which are reproduced in Table 115.

TABLE 115.—*Analyses of water from Little Scioto River above and below the Marion sewers' outfall.*

[Parts per million.]

Place of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.	Number of analyses constituting average.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
Above Marion	3	0.489	0.378	0.013	1.25	5.3	469	204	75	8,200	6
Below Marion	3	.464	1.897	.037	1.31	16.5	553	231	85	9,500	6

The report of the analyses of water from Little Scioto River, taken below the Marion sewer outlets, shows clearly the foulness of the contribution which the system receives from this tributary.

The next point of examination of the Scioto below the confluence of Little Scioto is the Ohio Girls' Industrial Home, which contains a population of over 400. A complete system of sewers is here provided, the wastes from which are poured directly into the river. Table 116 shows clearly the effects of this contamination upon the stream.

TABLE 116.—*Analyses of water from Scioto River above and below the Ohio Girls' Industrial Home.*

[Parts per million.]

Place of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.	Number of analyses constituting average.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
Above industrial home	3.0	0.334	0.086	0.008	0.176	6.6	509	175	123	1,600	3
Below industrial home	3.0	.320	.103	.009	.206	7.5	507	173	126	1,600	5

The next important center of pollution is the city of Columbus, where enters Olentangy River, the largest stream tributary to the Scioto. Above the confluence of these two rivers the State Board of Health has made three series of examinations, one at Wyandot Grove, above Columbus pollution, another about 3 miles below at Jones's dam, where the city's sewage begins to have effect; and a third at Sandusky street bridge, near the mouth of the Olentangy. The results of this interesting series of examinations appear below.

TABLE 117.—*Analyses of water from the Scioto River at Wyandot Grove.*

[Parts per million.]

Date of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1898.											
June 13	2.0	s[a]	0.260	0.040	0.002	0.200	4.0	445	194	52	730
July 17	3.0	.....	.378	.028	.002	.170	5.5	500	182	94	910
August 23	2.0	None.	.344	.096	.003	.030	3.8	440	172	88	290
September 23	1.5	e	.316	.098	.002	.030	7.8	550	176	126	300
October 21	2.0	e	.268	.048	.002	.050	7.7	585	200	140	200
December 3	5.0	e	.366	.100	.020	6.300	1.5	467	146	132	2,000
Average	2.5	.....	.322	.068	.005	1.150	5.0	498	178	105	740

[a] s, sweetish; e, earthy.

TABLE 118.—*Analyses of water from Scioto River at Jones's dam.*

[Parts per million.]

Date of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1898.											
June 23	2	None.	0.276	0.037	0.002	0.340	4.5	455	194	48	810
July 17	3	None.	.398	.028	.003	.200	3.8	510	184	104	400
Aug. 23	2	m[a]	.380	.092	.003	.080	4.1	450	178	80	590
Sept. 23	2	e	.306	.088	.003	.000	7.3	510	176	116	350
Oct. 21	2	e	.296	.082	.006	.050	7.4	454	192	124	700
Dec. 3	5	e	.354	.102	.025	6.500	1.7	464	140	136	2,200
Average	3	.....	.335	.071	.007	1.20	4.8	489	177	101	840

[a] m, moldy; e, earthy.

TABLE 119.—*Analyses of water from Scioto River at Sandusky street bridge.*

[Parts per million.]

Date of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1898.											
June 13	2.0	None.	0.342	0.110	0.007	0.320	7.0	480	190	62	1,470
July 17	3.0	M[a]	.376	.048	.002	.260	4.0	480	184	92	1,030
Aug. 23	2.0	M	.394	.200	.015	.070	10.1	445	180	78	4,540
Sept. 23	2.0	M	.420	.280	.005	.000	11.5	460	152	106	10,800
Oct. 21	1.5	d	.392	.086	.004	.040	8.7	525	158	98	1,150
Dec. 3	6.0	d	.418	.110	.025	5.820	2.3	474	144	136	10,200
Average	2.5	.....	.390	.139	.010	1.090	7.2	477	168	95	4,900

[a] M, musty; d, disagreeable.

OLENTANGY RIVER.

The Olentangy drains an extremely narrow basin lying east of and running parallel throughout the greater part of its length to the middle section of the main river. It rises in the northern part of Morrow County and flows for a short distance northwestward into Crawford County, passing the city of Galion, whence it takes a southerly course, running within 5 miles of the city of Marion, and after flowing through Delaware County and past the city of Delaware enters the Scioto at Columbus.

The highest point of pollution on Olentangy River is Galion, a city of 7,282 inhabitants. The population above this city is sparse, and the water in the river is therefore nearly normal. The State Board of Health conducted in the year 1898 a series of analyses of the water in the river above and below the outlet of Galion sewers, the average results of which appear below in Table 120. As the analyses indicate, the effect of Galion sewage on the river is marked.

TABLE 120.—*Analyses of water from Olentangy River above and below Galion.*

[Parts per million.]

Place of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.	Number of analyses constituting average.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
Above Galion	3.5	M[a]	0.476	0.132	0.007	0.640	8.3	463	208	69	450	5
Below Galion	3.5	M	.994	4.696	.111	.640	50.7	873	262	190	49,000	5

[a] M, musty.

The point of pollution worthy of consideration next below Galion is Delaware, the largest city in and the county seat of Delaware County. Many tributaries enter the river between these two cities, so that the stream is many times larger at Delaware than it is 40 miles above, at Galion. The water in the river above Delaware is markedly improved, as might be expected, but after receiving the contents of the city sewers the conditions are again undesirable, as shown in the following table:

TABLE 121.—*Analyses of water from Olentangy River above and below Delaware.*

[Parts per million.]

Place of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.	Number of analyses constituting average.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
Above Delaware	3.5	M[a]	0.322	0.073	0.004	0.860	2.5	408	186	61	1,030	6
Below Delaware	3.5	M	.357	.118	.017	.810	14.5	484	188	96	1,130	6

[a] M, musty.

There are of public record two series of analyses in the lower part of Olentangy River. The sampling point at Olentangy Park is above the serious pollution of Columbus, while the other is at Dublin Bridge, in the city of Columbus, just above the confluence of the Olentangy and Scioto rivers.

TABLE 122.—*Analyses of water from Olentangy River at Olentangy Park.*

[Parts per million.]

Date of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1898.											
July 16	3.0	e[a]	0.426	0.062	0.003	0.240	3.0	390	178	50	680
Aug. 24	2.5	None.	.334	.094	.003	.050	5.8	450	206	74	700
Sept. 23	3.0	e	.354	.076	.002	.000	10.2	555	204	134	400
Oct. 21	2.0	e	.286	.072	.005	.120	7.7	620	226	122	280
Dec. 3	5.0	e	.362	.066	.020	4.950	3.0	404	126	98	1,800
Average	3.0	.....	.353	.074	.007	1.070	5.9	484	188	96	770

[a] e, earthy.

TABLE 123.—*Analyses of water of Olentangy River at Dublin bridge, Columbus.*

[Parts per million.]

Date of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1898.											
June 13	2.0	e[a]	0.294	0.066	0.011	0.210	5.5	415	202	48	1,150
July 17	3.0	....	.388	.058	.004	.320	3.2	360	166	44	1,600
Aug. 23	2.0	M	.302	.096	.002	.020	5.4	440	194	72	2,100
Sept. 23	2.0	M	.352	.126	.001	.000	8.5	525	192	110	770
Oct. 21	1.5	M	.294	.036	.002	.000	8.7	585	218	112	520
Dec. 3	10.0	M	.372	.074	.020	4.800	3.0	387	132	96	4,000
Average.	3.4	....	.334	.076	.007	.890	5.7	452	184	80	1,700

[a] e, earthy; M, musty.

The analyses in Table 123 show the character of the water contributed to the Scioto system by its main tributary. Comparison of the various tables of analyses of the water of the Olentangy will show that at the mouth of the river the condition of the water is far better than it is below Galion, near its headwaters. Along the lower length of the river, however, the water is highly polluted and is unfit for use as a public supply without purification. The other values of the river are not seriously impaired, but as its resources are confined almost entirely to those of water supply, there is little that remains as available assets.

Below the confluence of the Scioto and the Olentangy the bed of the main river is very flat, so that it becomes in places almost a slack-water stream. The storage advantages are thus increased, and the river has remarkable self-purifying powers. Below Columbus the first sampling point is Frank road bridge, which is situated well down toward the lower part of the city. Analyses of the water taken at this point show the effect of the mixture of the upper Scioto and Olentangy waters and the sewage from Columbus.

TABLE 124.—*Analyses of water from the Scioto River at Frank road bridge, Columbus.*

[Parts per million.]

Date of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1897.											
June 11	2.0	d[a]	1.130	2.322	.....	0.030	16.0	495	238	86	8,900
July 17	4.0	d	.896	1.644	0.188	.000	13.0	440	182	84	64,000
August 23	4.0	d	1.136	3.824	.000	.000	21.0	520	256	94	195,000
September 23	3.0	d	.876	7.600	.....	.000	39.0	680	330	112	250,000
October 21	5.0	d	2.340	10.170	.000	.000	41.5	765	346	92	183,000
December 4	4.0	o	.780	.880	.070	4.420	6.0	472	160	134	135,000
Average	4.0	....	1.193	4.406	.043	.74	22.7	562	252	100	140,000

[a] d, disagreeable; o, oily.

Seven miles below Frank road bridge is Shadeville bridge, at which a series of analyses was made, the average results of which are reproduced in the table below:

TABLE 125.—*Analyses of water from the Scioto River at Shadeville bridge.*

[Parts per million.]

Place of collection.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.	Number of analyses contributing to average.
		Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
Shadeville bridge	3.5	0.806	3.352	0.121	0.121	19.3	510	285	74	7,200	5

Circleville is a village of 6,991 inhabitants, situated near the central part of Pickaway County, about 30 miles below Columbus. A series of examinations made of the river water taken at Main street bridge has been made by the State Board of Health, the reports of which are set forth in Table 126.

TABLE 126.—*Analyses of water from the Scioto River at Circleville.*

[Parts per million.]

Date of collection.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per c. c.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
1897.											
July 22	10.0	e[a]	0.660	0.118	0.030	1.13	1.7	285	114	54	14,000
Aug. 26	2.0	.....	.378	.352	.023	.16	5.5	395	228	20	600
Sept. 27	1.5	e	.320	.210	.007	.....	11.7	400	242	28	500
Oct. 25	2.5	M	.314	.534	.045	.13	11.2	435	282	28	800
Dec. 4	5.0	M	.424	.344	.050	2.68	2.5	393	144	76	3,500
Average.	4.0	.....	.419	.312	.031	.82	6.5	382	202	41	3,900

[a] e, earthy; M, musty.

It will be seen that the water at Circleville has been purified to a considerable extent in its course from Columbus down. Free ammonia, nitrites, and chlorine, the standard indicators of sewage pollution in water, are very much reduced, and the analyses at the lower point indicate better conditions.

The only important point of pollution below Circleville is the city of Chillicothe, containing 12,975 inhabitants. No analyses of water taken below this place are recorded. Sixty miles below Chillicothe the river enters the Ohio at Portsmouth.

Little remains to be said concerning the Scioto. The conditions of the river are wholly favorable to the purification of foreign matters that are poured into it, but the raw sewage it receives from the various cities constitutes a source of contamination that can not be overcome. The river is little more than a dumping ground for refuse, and its misuse affords a good example of the wanton destruction of a valuable resource; but the work of the State Board of Health of Ohio bids fair to be fruitful, so that we may confidently expect great improvements in sanitation in the Scioto Valley.

OHIO RIVER AT CINCINNATI.

On Ohio River, below the mouth of the Scioto, a series of notable investigations has been made by Mr. George W. Fuller, following his work on the water supplies of Louisville and Cincinnati, and the reports of these inquiries are probably the ablest that have been presented on the subject in this country. The Cincinnati report, in a concise, definite, and methodical manner, gives just the facts necessary to the discussion, and shows the character of the water of the Ohio as it comes down to Cincinnati, bearing traces of all the pollution heretofore considered, as well as a large amount derived from tributaries that have not yet been investigated, or the investigations of which are not of public record. Therefore one can arrive at an

understanding of the character of the Ohio River at this point no better than by consulting the above-mentioned report, parts of which are, for convenience, here reproduced.[a]

At the outset it is imperative, for a clear understanding of this report, that there should be fixed in mind the two most characteristic features of the local river water, as follows:

1. The wide range in the amount of suspended matter present in the water.
2. The great variations in the nature of the suspended matter, and especially in the size of the particles.

A comprehensive idea of the amounts of suspended matter found at different times in this water during the year 1898 is shown in the following summary:

TABLE 127.—*Turbidity of Ohio River water.*

[Parts per million.]

Number of days, 1898.	Corresponding range of suspended matter.	Number of days, 1898.	Corresponding range of suspended matter.
0	(a)	29	501–1,000
41	11– 50	5	1,001–2,000
63	51–100	1	(b)
127	101–250	Average	230
99	251–500		

a Less than 10. b Over 2,000.

The great variation in the character and size of the suspended matters is best illustrated by the following table, in which there is indicated the different hydraulic subsiding values (or sizes) of two extreme types of the river water. Type I is characteristic of the water during the early portion of a heavy freshet, when it is heavily laden with silt and fairly coarse clay, and Type II is representative of the water during later portions of rises, while it is charged to a greater relative degree with very fine, minute particles of clay.

TABLE 128.—*Periods of subsidence necessary with water from Ohio River at Louisville, Ky.*

Period of subsidence (hours).	Suspended matter in parts per million.		Per cent removed.	
	Type I.	Type II.	Type I.	Type II.
0	2,333	205	0	0
1	932	81	60	55
3	653	80	72	56
6	396	79	83	56
12	350	73	85	58
24	300	61	87	63
48	259	44	89	67
72	210	36	91	70
96	186	31	92	72

Between Types I and II there are found in the course of a year an almost endless number of intermediate combinations.

* * * * * * *

The direct causes of these variations in the Ohio River water are the rises or freshets which are so characteristic of this stream. Indirectly there are a number

a Report on investigations into the purification of the Ohio River water, 1899, p. 9 et seq.

of factors which exert much influence. Among them are the amount, rate, distribution, and frequency of the rainfall in the valley, and also the surface geology, topography, area, and length of the watershed, and the condition of the soil at the time of heavy rains. To solve the problem of establishing the relation between the composition of this river water and the factors affecting it is a complex matter; and so far as our knowledge goes there are available no adequate data for the purpose, nor are such data being obtained.

* * * * * * *

The watershed of the Ohio River above the intake of the new Cincinnati waterworks at California has an area of about 70,600 square miles. This area includes portions of the States of Ohio, New York, Pennsylvania, Virginia, North Carolina, West Virginia, and Kentucky.

Above the intake of the Front street pumping station (used during these tests) the area of the watershed is estimated at 72,400 square miles. In addition to the area at the new intake the last area includes that of the watershed of the Little Miami River, and that of the Ohio River itself between the Little Miami and the Front street intake, a distance of about 6 miles.

About half a mile downstream from the Front street intake the Licking River empties into the Ohio River on the Kentucky side. At this point the normal width of the river is about 1,000 feet. The Front street intake is situated about 200 feet from the Ohio shore, and in a straight line is distant about 4,000 feet from the mouth of the Licking. Under some conditions of river stages and of windstorms the waters of the Licking reach the Front street intake.

The Licking River has a watershed of about 3,300 square miles. Adding this to the above, there is obtained 75,700 square miles as a total area of the watershed of the Ohio River above the present intake opposite the city.

TABLE 129.—*Table showing the monthly rainfall in inches at various stations in the Ohio River Valley for the year 1898.*

Station.	Jan	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Cincinnati, Ohio..	7.76	2.21	6.70	1.15	3.03	1.58	3.26	2.61	2.62	2.90	2.69	2.46	38.97
Portsmouth, Ohio	10.03	1.69	5.14	2.05	3.53	3.13	5.27	6.92	1.97	3.59	2.54	2.76	48.62
Catlettsburg, Ky.	8.05	2.48	6.93	2.19	4.83	4.52	4.84	6.93	2.10	4.14	2.65	2.83	52.49
Point Pleasant, W. Va	8.04	1.93	5.81	1.48	3.51	2.87	2.79	6.40	2.07	3.15	2.67	2.57	43.29
Parkersburg, W. Va	5.73	2.24	5.43	2.17	2.76	4.98	4.38	4.66	2.09	3.90	2.50	2.16	43.00
Marietta, Ohio	5.74	2.39	6.03	2.30	2.77	5.04	5.20	5.31	3.69	4.24	3.15	2.21	48.09
Wheeling, W. Va.	4.79	2.50	5.15	3.72	3.63	2.98	5.81	7.82	3.24	3.37	2.66	3.03	48.93
Pittsburg, Pa	3.40	1.60	5.45	1.60	3.99	3.98	2.56	4.01	1.06	3.85	2.34	1.90	35.74
Oil City, Pa	5.32	2.53	5.74	2.13	4.64	4.56	4.45	6.73	2.11	5.18	4.33	2.90	50.62

TABLE 130.—*Table showing the normal monthly rainfall in inches at various stations in the Ohio River Valley.*

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Cincinnati, Ohio..	3.5	3.7	3.3	3.2	3.4	4.4	3.4	3.7	2.4	2.4	3.3	3.2	39.9
Portsmouth, Ohio	3.5	3.2	3.5	3.2	3.5	4.0	3.9	3.4	2.8	2.8	2.9	3.5	40.2
Catlettsburg, Ky.	4.3	4.0	4.2	3.2	4.0	3.8	4.4	3.6	2.9	2.7	3.5	2.9	43.5
Point Pleasant, W. Va	3.5	4.1	3.9	3.7	3.5	4.2	4.4	4.0	2.4	2.4	3.1	2.7	41.9
Marietta, Ohio	3.1	3.1	3.2	3.3	3.9	4.1	4.4	3.9	3.1	3.1	3.1	3.4	41.7
Parkersburg, W. Va	3.9	3.8	3.0	3.2	3.5	4.0	4.4	3.8	3.1	2.3	2.8	2.3	40.1
Wheeling, W. Va.	3.4	3.1	2.6	2.8	4.1	3.7	3.7	4.1	2.8	2.6	2.7	3.0	38.6
Pittsburg, Pa	2.6	2.5	2.8	3.0	3.5	3.6	4.0	3.4	2.9	2.8	2.6	2.9	36.6
Oil City, Pa	3.3	3.6	2.8	2.7	3.9	4.6	3.6	2.7	3.4	2.6	3.2	2.8	39.2

COMPARISON OF THE FREQUENCY, INTENSITY, AND DURATION OF RISES OR FLOODS IN THE OHIO RIVER AT CINCINNATI DURING 1898 WITH THE NORMAL.

This subject is one of great importance from a practical standpoint, because it deals with factors which directly produce the large quantities of and variations in the matters suspended in the river water. In view of the fact that these suspended matters are a point of vital significance in connection with the construction of an applicable system of clarification and purification, and also in the efficiency and economy of its operation, it is necessary to know, at least in general terms, how nearly normal was the suspended matter during these tests, and further, it would be very desirable to be able to foretell the conditions with regard to the suspended matters due to rises, as an aid in the operation of a plant.

To accomplish these purposes involves a study of the frequency, intensity, and duration of the rises in the river. It is an easy matter to deal with the first of these factors, except when the rises overlap each other; but to establish a relation between suspended matter, both in amount and character and the intensity and duration of rises, is a very difficult and perplexing problem. At the beginning of a freshet the rapidity with which the water rises seems to be a great factor, and the more rapid is the rise the greater is the amount of suspended matter and also the percentage of silt. When the rise is of a long duration it is found that, with the waters coming from the head of the valley, the weight of suspended matters gradually decreases, but the percentage of clay steadily increases, owing to the deposition of silt in the stream itself.

Just how it is best to arrange the available data to throw light upon these points is not wholly clear to us, since all efforts in this direction are wholly arbitrary and of necessity incomplete. However, it is believed that a comparison of the intensity and number of rises in the river with the rises for the past ten years will give as good a comparison for this purpose as can be obtained. In the following table, therefore, are given the number of days on which the river was rising moderately, rapidly, very rapidly, and when there was developing an extreme freshet:

TABLE 131.—*Number of days in the year on which the Ohio River was rising at various rates during the last ten years.*

Year.	Rate of rise in feet per day.			
	1.0–2.9.	3.0–5.9.	6.0–11.9.	Over 12.
1889	66	12	3	0
1890	63	31	4	0
1891	44	24	4	0
1892	33	10	5	1
1893	34	23	2	0
1894	24	8	4	0
1895	26	11	5	1
1896	47	24	2	0
1897	45	21	2	1
1898	54	25	7	0
Average	44.6	18.9	3.6	0.3

TABLE 132.—*Summary of amounts of the several constituents found in water of Ohio River during the year 1898.*

Constituent.	Parts per million.		
	Maximum.	Minimum.	Normal.
Total suspended matter	2,333.0	24.0	230.0
Suspended organic matter (nitrogen as albuminoid ammonia)	0.758	0.022	0.200
Total dissolved residue	223.0	67.0	120.0
Total nitrogenous organic matter	0.868	0.106	0.290
Nitrogen as free ammonia	0.074	0.008	0.025
Nitrogen as nitrites	0.030	0.000	0.003
Nitrogen as nitrates	1.34	0.37	0.60
Chlorine	44.0	3.0	10.0
Sulphuric acid	46.0	13.0	24.0
Normal hardness	57.0	11.0	33.0
Alkalinity	70.0	20.0	45.0
Microscopic organisms per cubic centimeter	40.0		
Carbonic acid	47.0	6.0	26.0
Bacteria per cubic centimeter	150,000	1,000	20,000

Odor.—The river water ordinarily has a slight odor characteristic of surface waters, the nature and intensity of which are somewhat variable. At different times the odor is musty, aromatic, resinous, and vegetable. The latter is most noticeable after heavy rains during the warm portions of the year. These odors become more pronounced upon heating the water, but, so far as noted during these tests, there is a practically complete absence of disagreeable or objectionable odors.

Color.—Independent of the suspended matter in it the normal river water is practically colorless, although in absolute terms it contains a small but measurable amount of color. It seems quite probable that, at times following certain kinds of rises in the river, there is an appreciably larger amount of dissolved color in the water than is normally the case; but experience shows that ordinarily it is easier to remove the unusual amounts of dissolved color than is the case with the finest particles of suspended clay. After passage through a Pasteur filter or a fine paper filter the water contains no color which is ordinarily visible.

Taste.—Ordinarily the river water has an earthy taste, which, however, does not become disagreeable except at times of great turbidity. Freed of its suspended matter, this water has a very satisfactory and agreeable taste.

Appearance.—The turbidity of the river water is such that its appearance is almost always unsatisfactory and uninviting, and for about half of the time it is so turbid that it is repulsive when considered for domestic use.

Weight of suspended matters.—When expressed in parts by weight per million parts of water by volume, the suspended matters in this water normally range from 20 to 2,500 and average about 230 parts.

Character of suspended matters.—In character as well as in amount of suspended matter the river water possesses a wide and rapidly changing degree of variability. The water in the course of the year contains an almost endless combination of varying proportions of fine sand made up of particles of quartz and hard silicates, with high specific gravity and a diameter larger than 0.002 inch; of silt with its intermediate size, specific gravity, and composition; and of very fine clay particles of aluminum silicate, with varying degrees of hydration, of low specific gravity, and of a size ranging from 0.0002 inch to less than 0.00001 inch.

Amount of organic matter.—The organic matter in the river water ranges from an amount which is fairly normal for Eastern waters to quantities (during rises) which are excessive, as judged by the data for many years collected from rivers not located in this general section of the country. The local data summarized above are a striking proof of the fact that it is not the amount but the character of the organic matter which is of importance from a sanitary standpoint.

Character and stability of organic matter.—From the immediately adjoining portion of the watershed there is quite an amount of sewage pollution. Owing to the large dilution, the deleterious effect of this is greatly attenuated. By no means is it eliminated at times of comparatively clear water, but during rises this crude organic matter to a considerable degree seems to be united and attached to particles of suspended matter, and thus carried to the bottom.

The consequence of this dilution and sedimentation is that the water contains very little organic matter, except that of a fairly stable character coming from the washings of the surface of the earth. With water taken from the new intake, above the local sources of pollution, this will be true to a still greater degree.

Alkalinity.—The alkalinity is caused by the carbonates and bicarbonates of lime and magnesia, and in a measure corresponds to temporary hardness (bicarbonates). It is the alkalinity which measures the capacity of the water to decompose sulphate of alumina and other coagulating salts. This water contains an average and minimum alkalinity of 45 and 20 parts per million, respectively. By these amounts of alkalinity there can be decomposed, respectively, about 6.5 and 3 grains per gallon of sulphate of alumina of ordinary composition, assisted by the average absorption of chemical by the suspended matters in the water.

Incrusting constituents.—Those constituents of water which produce incrustations in steam boilers comprise the sulphates, chlorides, and perhaps nitrates of lime and magnesia. In this water they are present (on an average of 33 parts per million) to a degree greater than in most of the Eastern waters, but smaller than in the waters farther west. On the whole, this water is a good one for boiler purposes, so far as incrusting constituents are concerned.

Gaseous constituents.—Atmospheric oxygen is apparently present in this water during cold weather to about the limit of saturation, and during the warm season there is contained in the water rather more oxygen than is the case with some surface waters, although the quantity at times becomes only about 40 per cent of that found during the winter. Carbonic acid (carbon dioxide) is present in this water to a degree which is apparently high, according to the limited data available from Eastern sources, but much lower than is the case with waters farther west coming from limestone regions.

Taking together atmospheric oxygen and the carbonic acid, they make the natural conditions quite favorable for the corrosion of unprotected iron receptacles, but the corrosion of lead pipes is promptly arrested by the action of dissolved constituents of the water itself.

Numbers and kinds of bacteria.—On an average the numbers of bacteria in the

river water (about 20,000 per cubic centimeter) are rather higher than in the ordinary river water. The range is also very great, 1,000 to 150,000, and is associated very intimately with the rises of the river.

At the present point of intake, opposite the city, a considerable number of the bacteria are of sewage origin. These sewage bacteria will be largely absent apparently in the water taken from the new intake at California.

Microscopic organisms.—The turbidity of the Ohio River water was so great during the larger part of the year 1898 that the sunlight was excluded to a degree practically inhibiting the growth of algæ and similar micro-organisms. When the river water was low and fairly clear these organisms were present in considerable numbers, but did not become of practical significance. The dissolved constituents (such as nitrates) in the river water, and especially at times of low water, are well adapted, however, as a food for the organisms which also require sunlight for their development.

TABLE 133.—*Suspended matter in water of Ohio River at Cincinnati from January 10 to March 23, 1898, with corresponding stages of height of river in feet.*

[In parts per million.]

Date.	Stage of river.	Suspended matter.	Date.	Stage of river.	Suspended matter.	Date.	Stage of river.	Suspended matter.
Jan. 10	33.0	2,333	Feb. 3	25.0	372	Feb. 24	33.0	221
11	32.2	1,151	4	21.5	184	25	33.2	332
12	35.4	1,024	5	18.7	134	26	32.4	170
13	38.0	719	6	16.5	113	27	30.7	123
14	37.7	578	7	14.7	108	28	28.0	141
15	39.7	470	8	14.0	96	Mar. 1	25.0	150
16	42.5	433	9	13.4	88	2	27.6	43
17	44.3	416	10	13.0	172	4	18.7	125
19	44.5	308	11	13.7	237	5	17.5	114
21	45.5	358	12	16.2	401	8	15.4	57
22	44.4	285	13	17.3	377	12	16.3	393
23	49.7	401	14	19.5	182	15	17.6	102
24	50.4	535	15	23.5	425	16	19.0	174
25	51.3	522	16	27.6	262	17	22.6	406
26	52.2	601	17	30.0	246	18	25.2	684
27	51.2	533	18	31.4	236	19	28.6	300
28	49.3	292	19	30.7	192	21	41.0	782
29	47.1	269	20	31.1	413	22	42.3	479
30	43.5	207	21	30.5	293	23	46.7	476
31	39.1	57	22	30.6	149			
Feb. 2	29.5	248	Feb. 23	30.6	310			

Of great importance as evidence of sewage pollution were the tests for Bacillus coli communis, which, as stated in previous pages, is an intestinal parasite. Mr. Fuller found that there was little room for

doubt that this germ was constantly present in the river water. He states:

From the evidence at hand it is probable that, by taking 2 cubic centimeters for each test, this germ would be found practically without exception. Upon taking 1 cubic centimeter for each test the identity of this bacillus was established in 60 per cent of the samples as shown by the results of tests, as follows:

TABLE 134.—*Result of tests (positive and negative) for Bacillus coli communis in Ohio River water at Cincinnati.*

Date.	Result.	Date.	Result.	Date.	Result.	Date.	Result.
1898.		1898.		1898.		1898.	
Mar. 24	−	May 2	+	June 7	+	Aug. 1	+
25	−	3	+	9	−	2	−
26	−	5	+	10	−	3	+
29	+	6	+	13	−	5	+
31	+	7	−	15	+	6	+
Apr. 1	−	8	−	16	+	7	+
2	−	9	+	18	−	9	−
3	−	10	+	19	+	10	+
4	−	11	+	20	+	12	+
5	+	12	+	24	+	13	+
6	+	13	−	25	+	15	+
7	−	14	+	28	+	16	+
8	+	16	+	29	−	18	+
9	+	17	+	30	+	19	+
10	−	18	−	July 1	+	20	+
11	−	19	+	2	+	22	−
12	−	20	−	4	+	23	−
13	+	21	−	7	+	24	+
14	−	22	−	8	+	27	+
15	+	23	+	9	+	30	−
16	+	24	+	10	+	31	+
17	−	25	−	13	+	Sept. 2	+
18	+	26	+	14	+	3	+
20	+	27	+	16	+	5	−
21	−	28	+	18	+	9	+
22	+	29	−	19	+	10	-
23	+	30	−	20	+	13	+
25	+	31	+	22	−	14	−
26	−	June 1	−	23	+	15	+
27	−	2	−	25	−	16	+
28	−	3	+	27	−	17	+
29	+	4	−	28	+	18	−
30	+	6	+	29	+	21	−

TABLE 134.—*Result of tests (positive and negative) for Bacillus coli communis in Ohio River water at Cincinnati*—Continued.

Date.	Result.	Date.	Result.	Date.	Result.	Date.	Result.
1898.		1898.		1898.		1898.	
Sept. 22	+	Oct. 15	+	Nov. 7	+	Dec. 2	—
23	+	17	—	8	+	3	—
26	+	19	—	10	—	6	—
27	+	20	—	11	—	8	+
29	+	22	—	12	—	10	—
Oct. 1	+	23	—	16	—	13	+
3	—	24	+	17	+	15	+
5	+	27	+	19	—	17	+
7	—	28	+	20	—	20	+
9	+	28	+	21	—	21	+
10	+	30	+	24	—	24	+
11	+	Nov. 1	+	26	+	27	—
13	+	2	+	28	—	29	—
14	—	4	+	30	—		

MIAMI AND LITTLE MIAMI RIVERS.

The important tributaries entering the Ohio next below Scioto River are Miami and Little Miami rivers. They occupy the most elevated portions of Ohio, and the drainage basin of the larger river extends into Indiana. Taken altogether, the area drained by the two rivers covers 6,950 square miles, of which 5,601 lie in Ohio. (See fig. 17.) The population in the basin is 641,657, or about 92 per square mile. Thirty cities and villages, representing a population of 242,762, have water supplies. This is 91 per cent of the urban population in the river basin and 44 per cent of the entire population. Fifteen of the cities have been supplied with sewerage systems, all of which discharge into the neighboring streams without previous purification.

LITTLE MIAMI RIVER.

The drainage basin of the Little Miami River occupies a small, wedge-shaped portion of the State of Ohio lying between the basins of the Scioto and Miami rivers and fronting at the broad southern end on Ohio river. From its headwaters to its confluence with the Ohio the Little Miami traverses 94 miles and has a total fall of 696 feet, or 7.4 feet per mile. The tributaries of the Little Miami are Cæsars Creek, Todds Fork, and the East Branch of the Little Miami, the latter, draining an area of 475 square miles, being the most important.

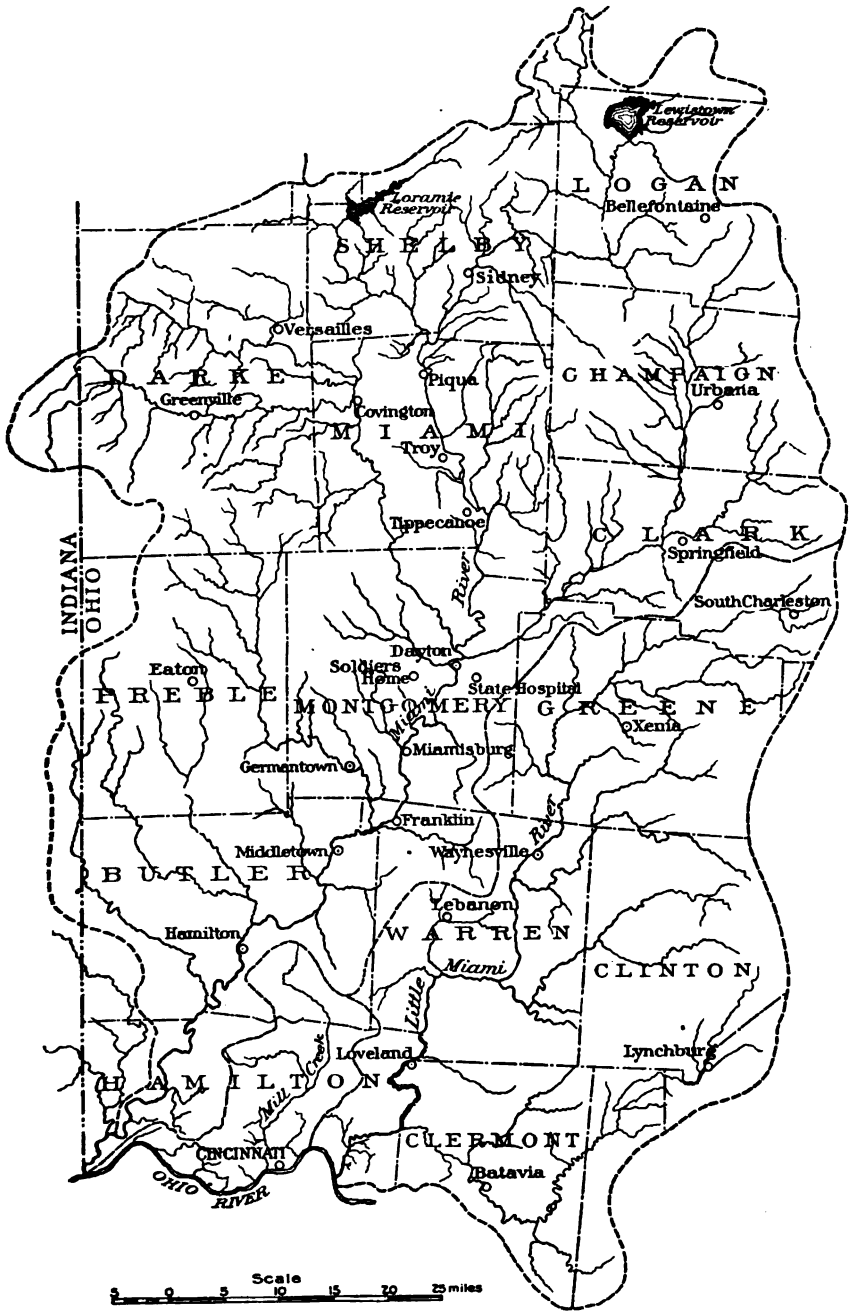

FIG. 17.—Drainage basins of Miami and Little Miami rivers.

The drainage area of the Little Miami is almost entirely devoted to farming. It is a prosperous country, with a rural population of 81,314 and an urban population of only 39,645. Sewage pollution from cities is, therefore, not so important here as in other areas which have been studied; but the run-off water from highly fertilized fields shows on analysis a large proportion of organic constituents which, if interpreted from the analysis alone, without special acquaintance with the origin of the water, would perhaps indicate a high degree of sewage pollution.

At the headwaters of the river, in Clarke County, the first important settlement is South Charleston, which has a population of 1,096. There are three short sewers in the village, and the water supply is from private wells 15 to 20 feet deep. South Charleston can therefore be considered the head of pollution upon Little Miami River. Above this place the waters are probably free from specific sewage contamination. Analyses show, however, that the organic matter is extremely high, due undoubtedly to the run-off from manured fields and rank decay of vegetable growths.

TABLE 135.—*Analyses of water from Little Miami River above South Charleston.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per cubic centimeter.	Rainfall during previous 10 days.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
1901.													*Inches.*
May 28	47	26	e[a]	0.200	0.138	0.042	1.24	.....	354	225.8	66.0	3,800	0.72
June 26	144	40	v	.442	.282	.090	.66	.....	390	239.4	39.8	2,200	.89
July 17	120	30	v	.522	.230	.022	.06	1.5	438	290.2	7.4	3,800	.74
Aug. 20	130	30	e	.540	.156	.018	.....	0.0	349	221.8	36.2	2,800	1.59
Oct. 18	95	23	v	.242	.080	.013	.000	0.0	362	223.2	00.0	3,400	.03
Nov. 7	100	29	v	.356	.112	.018	.000	4.0	423	266.2	00.0	3,000	.23

[a] e, earthy; v, vegetable.

The analyses set forth in the above table indicate a water of comparatively high organic content. The testimony of the free ammonia and nitrite determinations would seem to indicate a fairly high degree of sewage pollution, but this is not borne out by the remainder of the analytical statement. The water can not be regarded in any sense as normal, but it is probably free from dangerous impurities.

Below South Charleston, on Little Miami River, are Clifton and Yellow Springs, with populations of 262 and 1,371, respectively, producing no appreciable contamination of the surface drainage.

On Massicks Creek, which enters the Little Miami just above Xenia,

are situated Cedarville and Wilberforce College. At the former place a strawboard works contributes the usual amount of deleterious matter, while at the college a part of the plumbing system is connected with the creek.

The water which comes down to Xenia in the channel of Little Miami River has received the pollution from several unimportant settlements, but most damaging refuse comes from the strawboard works at Cedarville. Analyses of the water (see Table 136) indicate that, from a chemical standpoint, it is of as good quality as that found at the headwaters, above artificial pollution. The bacteriologic examination, however, is indicative of an organic content more highly putrefactive than that which was present in the water above South Charleston.

TABLE 136.—*Analyses of water from Little Miami above Xenia.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per cubic centimeter.	Rainfall during previous 10 days.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
1901.													*Inches.*
Apr. 26	45	20	v[a]	0.220	0.082	0.028	1.17	1.1	335	223.8	18.4	44,000	0.96
May 28	80	28	v	.270	.230	.084	.70	.5	396	234.8	27.8	120,000	1.35
June 28	175	38	v	.314	.174	.068	.67	.8	423	260.8	00.0	4,800	.96
July 17	142	30	v	.794	.280	.056	.03	.7	374	260.8	00.0	1,700	.38
Aug. 22	110	43	v	.296	.090	.030	.02	.0	369	230.2	22.2	17,000	2.92
Sept. 17	50	16	v	.226	.066	.022	.06	1.4	315	235.8	00.0	3,200	.18
Oct. 18	48	35	M	.302	.136	.009	.0	.8	386	269.8	00.0	180,000	.05
Nov. 9	28	65	v	.306	.006	.010	.12	1.9	368	287.2	00.0	80,000	.23

[a] v, vegetable; M, musty.

Below Xenia the water of the Little Miami does not seem to be inferior to that above. Although the city has a population of 8,696, no sewers have been established, and the contamination of the river is not so great as might be expected from a municipality of this size. Xenia is not situated directly upon Little Miami River, but some distance up a small stream called Shawnee Run. The greatest source of pollution about Xenia is the Ohio Soldiers and Sailors' Orphans' Home, situated on Shawnee Run, southeast of Xenia. This home has an average population of 1,010, and has its own water supply and sewerage system connected with the stream.

TABLE 137.—*Analyses of water from Little Miami River below Xenia.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per cubic centimeter.	Rainfall during previous 10 days.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
1901.													*Inches.*
Apr. 26	45	26	v[a]	0.286	0.020	0.032	1.28	1.6	362	240.2	13.8	62,000	0.96
May 28	87	32	v	.292	.310	.058	.89	4.8	418	254.4	7.0	12,000	1.35
June 28	175	33	v	.328	.180	.036	1.04	2.2	383	221.6	32.0	5,100	.93
July 17	105	28	v	.314	.142	.032	.36	3.2	375	256.6	.0	1,200	.38
Aug. 22	90	38	v	.462	.070	.030	.00	.0	344	236.6	.0	177,000	2.92
Sept. 17	55	17	v	.282	.078	.022	.00	1.9	388	242.4	.0	2,600	.18
Oct. 18	54	33	M	.212	.134	.009	.00	1.7	380	252.4	.0	34,400	.05
Nov. 9	35	58	v	.324	.050	.010	.10	1.6	378	281.0	.0	148,000	.23

[a] v, vegetable; M, musty.

Proceeding down the river from Xenia, the most important points of pollution discovered are Waynesville, having a population of 723; Wilmington, on Todds Fork, inhabited by 3,613 people; Blanchester, on the same tributary, with 1,788 inhabitants; Lebanon, on Turtle Creek, with 2,867, below which is Loveland. At this point a series of examinations has been made by the State Board of Health of Ohio, the results of which are reproduced in Table 138.

TABLE 138.—*Analyses of water from Little Miami River above Loveland.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per cubic centimeter.	Precipitation during previous 10 days.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
1901.													*Inches.*
Apr. 24	40	18	v[a]	0.216	0.036	0.011	1.26	1.0	316	194.2	20.2	1,800	0.45
May 29	430	30	e	.332	.076	.018	.52	.8	483	157.6	15.2	21,000	1.67
June 26	250	15	m	.324	.096	.009	.40	2.2	389	238.8	12.4	1,500	.00
July 17	235	13	v	.254	.066	.026	.30	2.6	350	219.6	11.2	1,200	.39
Aug. 20	800	33	e	.312	.124	.024	.31	.0	338	128.2	20.6	8,000	.86
Sept. 17	103	20	e	.321	.036	.006	.00	2.8	316	210.0	.0	1,900	.00
Oct. 19	90	18	v	.220	.032	.006	.00	2.9	378	224.0	.0	2,100	.00
Nov. 9	60	26	e	.176	.022	.010	.00	2.7	343	221.2	.0	1,400	.27

[a] v, vegetable; e, earthy; m, moldy.

The analyses above set forth, when compared with those in tables 135, 136, and 137, indicate a considerable improvement in the general character of the water. Free ammonia and nitrites, which are indicative of sewage pollution, are present in the Loveland water in smaller proportion than in water taken higher up in the drainage area. The chlorine content, however, maintains the same high proportion, and is

an evidence of the contaminating influences of the municipalities above mentioned.

EAST FORK OF LITTLE MIAMI.

Below Loveland enters the East Branch of Little Miami River, the principal centers of population on which are Lynchburg and Batavia. At the former place a surprisingly large amount of refuse is discharged into the stream from a distillery and from numerous drains which lead out of the town. At Batavia a public water supply has been established and a number of storm sewers conduct surface drainage into the stream. Tables 139 and 140 are reports of analyses made by the Ohio State Board of Health, which fairly indicate the character of the water above and below Batavia.

TABLE 139.—*Analyses of water from the East Fork of Little Miami River above Batavia.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per cubic centimeter.	Precipitation during previous 10 days.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
1901.													*Inches.*
Apr. 25	65	25	e[a]	0.300	0.044	0.001	0.03	2.1	270	154.8	39.0	3,200	0.65
June 1	95	33	v	.372	.018	.006	.14	.5	258	160.8	42.0	.....	1.49
June 27	70	25	v	.296	.148	.002	.12	.5	257	149.4	23.4	750	.77
July 20	86	25	m	.310	.118	.010	.04	.0	251	167.6	.0	2,100	1.71
Aug. 21	900	28	e	.332	.086	.012	.00	.0	307	80.0	.0	40,000	1.69
Sept. 19	116	23	v	.308	.080	.008	.00	1.1	238	135.4	50.2	2,300	.00
Oct. 19	165	28	v	.268	.036	.008	.00	2.2	251	111.4	10.2	5,400	.00
Nov. 8	70	28	v	.330	.034	.002	.08	4.6	233	121.8	6.8	1,500	.33

[a] e, earthy; v, vegetable; m, moldy.

TABLE 140.—*Analyses of water from East Fork of Little Miami River below Batavia.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per cubic centimeter.	Precipitation during previous 10 days.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
1901.													*Inches.*
Apr. 25	60	25	e[a]	0.350	0.052	0.002	0.02	2.4	299	157.6	63.8	3,500	0.65
June 1	95	33	v	.348	.032	.007	.16	1.1	277	161.2	19.4	.....	1.49
June 27	70	28	v	.266	.146	.010	.13	.9	261	143.2	73.8	1,300	.77
July 20	80	25	v	.302	.136	.010	.08	.9	262	195.2	.0	2,200	1.71
Aug. 21	800	28	e	.314	.104	.013	.00	.0	353	80.2	8.2	38,000	1.69
Sept. 19	110	23	v	.326	.102	.005	.00	1.8	246	139.0	.0	1,500	.00
Oct. 19	165	32	v	.234	.020	.005	.00	3.0	243	115.0	.0	6,000	.00
Nov. 8	65	25	M	.276	.034	.002	.04	4.4	230	124.4	23.2	2,900	.33

[a] e, earthy; v, vegetable; M, musty.

From the confluence of the East Branch the Little Miami flows southward and empties into the Ohio just above the city of Cincinnati. From the mouth of the East Branch to the confluence of the river with the Ohio the pollution is insignificant. Analyses of the water below Linwood, a suburb of Cincinnati, make it appear preferable to any reported from the drainage area above.

TABLE 141.—*Analyses of water from Little Miami River, below Linwood.*

[Parts per million.]

Date of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per cubic centimeter.	Precipitation during previous 10 days.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
1901.													*Inches.*
Apr. 24	35	13	v[a]	0.192	0.042	0.010	0.57	2.6	308	190.6	19.4	6,100	0.45
May 29	+3,000	25	e	.638	.097	.010	.18	0.5	1,529	106.6	26.4	30,000	1.67
June 26	187	23	v	.260	.118	.006	.08	3.2	345	212.8	3.0	3,000	.00
July 19	+3,000	25	e	.658	.134	.014	.10	1.3	1,913	127.6	25.2	43,000	1.53
Aug. 20	1,000	28	e	.246	.068	.022	.10	0.0	352	108.2	.0	7,300	.86
Sept. 18	120	23	e	.370	.076	.006	.00	3.4	326	205.8	.0	1,300	.00
Oct. 13	200	32	e	.302	.064	.006	.00	3.1	356	161.6	.0	3,900	[b]1.12
Nov. 8	40	25	e	.202	.026	.000	.04	4.1	302	229.2	8.6	1,200	.27

[a] v, vegetable; e, earthy.

[b] Storms one week previous.

The drainage basin of Little Miami River is without special interest from the standpoint of water pollution. As has already been observed the urban population is comparatively small and the sewage it contributes to the river does not seem to have very marked effects on the water. The analyses show a high content of organic matter from the headwaters down, and while the water may not have been much damaged it is certainly not so desirable for public use as some of the purer waters found in other parts of the State. It can hardly be said, however, that Little Miami River has suffered greatly from city or manufacturing refuse, and it is more than likely that if all sewage were removed from the stream and its tributaries the natural drainage of an area so highly fertilized would so change the character of the run-off water that it would be hardly acceptable for city water-supply purposes without filtration. The other resources vested in the natural waters of this area do not appear to be damaged appreciably.

MIAMI RIVER.

Entering Ohio below Cincinnati, the Miami River drains a basin to the north thickly dotted over with towns and cities. The main stream is formed at Dayton by the confluence of the Upper Miami, Stillwater, and Mad rivers, which have drainage areas of 1,158, 645, and 653 square miles, respectively. From Dayton to the mouth the river flows in a somewhat winding course to the southwest. From its

headwaters in Lewistown reservoir, in the extreme northern part of the drainage area, to its mouth the Miami has a length of 163 miles.

NORMAL WATER IN THE MIAMI BASIN.

In a drainage area like that of the Miami it is difficult to secure samples of normal water. The run-off from land given over to agriculture is seldom, if ever, of a quality which approaches the normal very closely. There appear, however, in the report of the Ohio State Board of Health for 1901 three series of analyses of water taken from streams which, so far as is known, bear no direct sewage pollution. These streams are Mad River above Urbana, Buck Creek, a tributary of Mad River, above Springfield, and Greenville Creek above Greenville City. The population upon the drainage area of these streams above the points named is of the usual agricultural nature, and the pollution of the run-off water is probably confined to the drainage of manured fields.

The analyses made by the Ohio State Board of Health are set forth below in Table 142.

TABLE 142.—*Analyses of nearly normal waters in the Miami River Basin.*

BUCK CREEK ABOVE SPRINGFIELD.

[Parts per million.]

Date of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per cubic centimeter.	Precipitation during previous 10 days.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
1900.													*Inches.*
Apr. 16	.....	10	None	0.104	0.016	0.005	0.84	0.4	407	242.0	2.98	325	0.54
May 24	25	10	v[a]	.328	.032	.010	1.14	.3	431	244.0	27.20	1,200	1.49
June 20	32	23	e	.096	.036	.008	.83	.2	428	268.0	12.00	375	.00
July 10	90	15	e	.176	.028	.010	1.06	.4	463	260.2	30.00	800	.33
Aug. 9	57	17	v	.184	.042	.010	1.64	.0	384	227.6	29.00	400	.00
Sept. 5	60	13	v	.206	.044	.011	1.46	.0	386	239.4	1.80	600	.40
Oct. 3	35	15	v	.112	.022	.002	1.63	.4	425	219.4	3.00	1,200	1.63
Nov. 3	16	17	None	.078	.019	.014	2.12	.5	399	249.4	13.20	1,000	.23

MAD RIVER ABOVE URBANA.

1900.													*Inches.*
Apr. 19	100	32	e	0.258	0.014	0.010	1.87	0.0	497	229.0	60.6	12,000	1.42
May 24	17	12	e	.104	.040	.010	.82	.5	347	265.4	3.0	700	.86
June 20	70	21	v	.170	.050	.009	.83	.0	434	271.8	26.8	1,700	.00
July 9	100	18	v	.220	.060	.017	.64	.2	410	266.2	11.4	2,200	1.05
Aug. 9	95	22	v	.182	.054	.016	1.04	.2	396	250.4	.0	3,300	.11
Sept. 5	165	28	e	.360	.032	.007	.83	.0	438	230.4	21.0	5,900	.25
Oct. 3	90	18	v	.130	.032	.006	1.26	1.0	462	260.2	1.6	4,000	1.31
Nov. 3	28	20	None	.066	.019	.005	.00	.0	390	251.4	1.4	2,200	.20

[a] v, vegetable; e, earthy.

TABLE 142.—*Analyses of nearly normal waters in the Miami River Basin*—Cont'd.

GREENVILLE CREEK ABOVE GREENVILLE.

Date of collection.	Turbidity.	Color.	Odor.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per cubic centimeter.	Precipitation during previous 10 days.
				Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.		
1900.													*Inches.*
Apr. 17	28	20	v[a]	0.188	0.090	0.016	3.44	0.2	449	217.8	83.0	3,300	0.60
May 22	24	28	v	.211	.094	.038	2.09	.0	380	226.2	40.0	1,100	1.22
June 18	28	25	v	.184	.084	.014	.55	.6	467	278.4	31.0	1,300	.00
July 10	70	27	v	.214	.060	.020	.44	.4	369	280.0	.0	1,100	.52
Aug. 7	65	22	v	.268	.134	.011	.00	2.7	421	255.4	3.2	2,000	1.68
Sept. 3	55	23	v	.186	.096	.010	.00	1.0	413	269.0	.0	4,700	.00
Oct. 1	120	42	v	.272	.063	.024	2.12	.0	432	189.6	35.0	19,000	3.22
Nov. 1	28	20	e	.164	.019	.002	.00	1.5	472	274.0	26.6	6,400	.35

[a] v, vegetable; e, earthy.

Inspection of the above table readily shows that the water in Buck Creek above Springfield is decidedly the best. Throughout the whole table the content of organic matter indicated is comparatively low and maintains a fair degree of uniformity. In the Buck Creek analyses the free ammonia, nitrites, and chlorine are much lower than in any analyses heretofore presented for this area. There is the same steadiness in the total residue column that was evidenced in the Little Miami examinations. Turbidity and bacteria per cubic centimeter are comparatively uniform in spite of the fact that there were wide fluctuations in the precipitation during the ten days previous to each examination.

Turning now to the three affluents of the Miami, let us consider the conditions existing within the drainage areas of each.

MAD RIVER.

Mad River has its origin in Logan County and flows with a general southwesterly trend to Dayton. The city of Urbana, with 6,808 inhabitants, lies at the head of sewage pollution. A water supply has been established in Urbana, but the sewerage system is confined to a few private lines of pipe. The principal source of pollution, however, is the highly contaminated run-off occasioned by the storage of polluting material in vaults and cesspools, rarely cleaned, but allowed to filter into the ground. The most important point of pollution is the city of Springfield, which has a population of 38,253.

Water and sewerage systems have been established, but the latter is said to be very poor, and only about 20 per cent of the population has access to it. The most flagrant source of pollution from Springfield is the method of disposing of garbage, night soil, and dead animals. These are dumped promiscuously into the river or buried on or near the banks. There is also considerable pollution from various industries.

There are available the results of analyses of series of samples

taken from Mad River above and below Urbana, above and below Springfield, and above Dayton; also from Buck Creek, above Springfield. The reports of the first and last named have already been given in Table 142.

In the following table the average results of monthly determinations at the above-named places are set forth:

TABLE 143.—*Analyses of water from Mad River.*

[Averages for eight monthly examinations, in parts per million.]

Place of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per cubic centimeter.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
Above Urbana	80	21	0.191	0.038	0.010	0.91	0.2	422	253.1	14.5	4,000
Below Urbana	115	47	.608	.039	.060	.47	1.2	456	278.7	16.5	160,000
Above Springfield	80	27	.260	.076	.028	.48	.5	431	272.1	12.1	9,500
Above Springfield (Buck Creek)	40	15	.154	.030	.009	1.34	.3	417	243.8	18.2	738
Below Springfield	75	24	.270	.201	.042	.60	3.3	435	270.6	9.2	31,000
Above Dayton	80	20	.194	.033	.011	1.32	2.8	417	254.8	14.0	6,750

Inspection of the above analyses shows the usual unmistakable evidences of contamination of the river from the two principal polluting points and the improvement of the water as it flows from one of these points to the other. The character of the water above Urbana on Mad River and above Springfield on Buck Creek has already been discussed. As the water passes by Urbana there is a notable increase in the content of organic matter as well as in turbidity and in the number of bacteria per cubic centimeter. From Urbana to Springfield the water shows undoubted improvement, but is again changed in passing the city of Springfield, while the analyses made of samples taken above Dayton show that the water has so far improved as to be, from a chemical standpoint at least, almost as good as it appears above Urbana. The Dayton samples show the character of the water contributed to the Miami system by Mad River.

UPPER MIAMI RIVER.

Upper Miami River has its origin in Lewistown reservoir and flows south by a somewhat circuitous route to join the Stillwater and Mad rivers at Dayton. The head of pollution upon the Upper Miami is Bellefontaine, a village of 6,649 inhabitants, supplied with water and a short system of storm sewers. The principal pollution from this point consists of the drainage of a few plumbing systems into the storm sewer, the refuse from slaughterhouses, and the pollution of run-off water through putrescible material stored in the ground. A few institutions, such as the Logan County Infirmary, Logan County Childrens' Home, and the Shelby County Childrens' Home and Infirmary, contribute more direct sewage pollution to the river than any of the small villages situated along the stream. The village of Sidney, having a

population of 5,688, has a water supply and has just introduced a system of sewers. These, together with a brewery and a tannery and various other incidental contaminating points, produce considerable damage to the river.

Next below Sidney is Piqua, having a population of 12,172. The public water supply at this point is not used for domestic purposes. A separate system of sewers, to which about 30 per cent of the people have access, has been established. These sewers empty directly into the Miami River. In the town are located strawboard works, oil mills, breweries, and several large slaughterhouses, and the effluent from these and the sewers is the occasion of serious nuisances at times.

Below Piqua is Troy, containing 5,581 inhabitants, and still farther down is Tippecanoe City, with 1,703. Both places have public water supplies and a few short, combined sewers, to which a small proportion of the people have access. Garbage and night soil are dumped along the river and into the Miami and Erie Canal, which flows along the river bank. In addition to the pollution from sewers, the river receives the refuse from three distilleries, two breweries, and several large slaughterhouses.

Chemical examinations of the water of the Upper Miami have been made above and below the cities of Sidney, Piqua, and Troy, and above Dayton, and the averages of the eight monthly analyses of samples taken at each point appear in the following table:

TABLE 144.—*Analyses of water from Upper Miami.*

[Averages of eight monthly examinations, in parts per million.]

Place of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per cubic centimeter.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
Above Sidney	60	23	0.295	0.066	0.009	0.52	0.7	404	219.8	33.3	1,900
Below Sidney	45	24	.289	.074	.014	.57	2.3	379	223.9	25.9	4,700
Above Piqua	290	28	.400	.077	.010	.65	1.2	484	200.6	31.9	11,000
Below Piqua	240	27	.374	.048	.027	.90	3.4	468	208.9	25.0	22,500
Above Troy	55	26	.344	.105	.018	.54	2.4	388	214.7	27.2	5,600
Below Troy	35	24	.378	.112	.019	.61	3.2	364	221.9	20.4	52,000
Above Dayton	100	25	.307	.049	.013	.68	1.5	407	220.9	24.9	5,600

The effect of sewage on the Miami River above Dayton, as indicated by the above analyses, is so obvious as hardly to merit discussion. The same general features, repeatedly observed in the discussion of drainage areas in previous pages, occur here. As the Miami enters the city of Dayton, the water, from a chemical standpoint, is only a little inferior to that in the same stream above Sidney.

STILLWATER RIVER.

Stillwater River, entering the Miami at Dayton, drains the country to the northwest, comprising large areas in Darke and Miami coun-

ties. The principal source of pollution along the entire length of Stillwater River is the city of Greenville, which has a population of 5,501. At this place water and sewerage systems have been installed, the latter being one of the best in the drainage area. In addition to the contaminating matter carried into the former from the sewers, there is the polluted surface drainage from that part of the town which has not yet been connected with the sewerage system.

In the drainage area of the Stillwater there are several institutions which furnish the usual amount of contamination. The villages of Versailles and Covington, containing 1,478 and 1,791 inhabitants, respectively, are the only remaining points within the watershed that are important from the standpoint of stream pollution.

Three sampling points were selected by the Ohio State Board of Health as a basis for their investigation into the character of the water in Stillwater River. These are located above and below Greenville, on Greenville Creek, and above Dayton.

TABLE 145.—*Analyses of water from Stillwater River.*

[Averages of eight monthly examinations, in parts per million.]

Place of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per cubic centimeter.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
Above Greenville	55	26	0.211	0.072	0.017	1.08	0.8	425	248.8	27.3	4,900
Below Greenville	70	27	.274	.091	.022	1.17	2.6	475	251.7	85.4	13,500
Above Dayton	80	23	.251	.041	.009	2.02	.9	380	218.9	8.3	45,500

Examination of the results above set forth shows nothing of an uncommon nature. Above Greenville, as has been already shown in the consideration of normal waters in the Miami drainage area, there is little evidence of specific sewage contamination. Below Greenville there is, as might be expected, an increase of those ingredients whose presence is generally accepted as an indication of pollution, but the amount of this increase is not so great as might be expected when all the circumstances are considered. The analyses of samples taken above Dayton indicate the usual improvement in a water after it has flowed beyond the point of contamination for a considerable distance.

The city of Dayton has a population of 85,333, the largest on the drainage area of the Miami. It is provided with a water supply and a sewerage system, to which 30 per cent of the people have access. Garbage is burned in a crematory and night soil is disposed of upon the farms outside the city, so that the pollution of the river is confined to the affluents from the sewerage system and the refuse turned into the stream by industrial plants, which consist of breweries, slaughter and packing houses, oil mills, soap works, and paper and strawboard manufactories.

MIAMI RIVER BELOW DAYTON.

Below the city of Dayton, on the Miami, are located the National Soldiers' Home and the Dayton State hospital. The combined population of these two institutions is 5,810. Both are provided with sanitary sewers and improved systems of plumbing, which discharge directly into the river. This is the largest center of pollution in the whole drainage area, greater, in fact, than the city of Dayton itself. Continuing down the river from the two institutions above mentioned, the next important point is Miamisburg, which has a population of 3,941. Industrial pollution seems to be the most important at this village, which has no water or sewerage system.

The village of Franklin, a few miles below Miamisburg, is inhabited by 2,724 persons and is supplied with water and a small system of sewerage. In addition to the contamination afforded by the latter, a large proportion of the garbage of the town is dumped into the river and some of the industrial plants, such as paper mills and slaughterhouses, pour their refuse into the stream.

Middletown is situated a few miles below Franklin, on the east bank of Miami River. It has an excellent water supply and sewerage system, through which the sewage of about 2,000 persons is carried directly into the river. The waste from a large number of manufacturing establishments also finds its way there. Among these are gas works, breweries, malt houses, etc.

A few miles below Middletown is the city of Hamilton, through the center of which Miami River passes. Hamilton has a population of 23,914, a good water supply, and an extensive system of sanitary and storm sewers. In addition to the polluting material poured into the river by these sewers, it receives the refuse from a large and varied assortment of industries.

Below Hamilton there is little of interest until the mouth of the river is reached.

Sampling points selected by the Ohio State Board of Health are below Dayton, above and below Middletown, above and below Hamilton, and below Cleves.

TABLE 146.—*Analyses of water from Miami River.*

[Parts per million.]

Place of collection.	Turbidity.	Color.	Nitrogen as—				Chlorine.	Total residue.	Hardness.		Bacteria per cubic centimeter.
			Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.			Alkalinity.	Normal hardness.	
Below Dayton	81	25	0.309	0.067	0.021	1.99	4.2	407	220.9	24.9	65,000
Above Middletown	215	27	.261	.045	.015	.46	3.3	432	212.2	18.5	19,000
Below Middletown	257	29	.340	.047	.022	.51	5.3	461	220.5	15.4	43,000
Above Hamilton	1,820	28	.345	.058	.012	.75	3.1	626	188.7	13.9	25,500
Below Hamilton	1,300	26	.361	.072	.018	.57	4.7	551	199.4	14.5	33,000
Below Cleves	2,250	26	.406	.056	.012	.63	3.9	813	191.7	12.4	7,000

The character of the water contributed to the Ohio system by the Miami is not all that could be desired, nor indeed as good as might easily be furnished. In the course of the river from Dayton to its mouth the changes in the organic constituents of the water are not exceedingly sharp. The undesirable condition of the run-off at Dayton is maintained steadily throughout the remainder of the course. The sewage of Dayton and the two institutions just below it is apparent in the report of the analyses of samples taken above Middletown. The additional polluting material poured in from Middletown is perfectly evident, and by the time the water reaches Hamilton only a very small improvement can be noted. The water contributed to the system by the three main affluents above Dayton seems to be far superior to that which flows by Cleves into Ohio River.

OHIO RIVER AT LOUISVILLE.

During the years 1895, 1896, and 1897 extensive investigations were carried on by the Louisville Water Company to determine the character of the water in Ohio River opposite that city. Mr. George W. Fuller was placed in charge of this work, and in the year 1898 submitted an exhaustive report on the purification of the water of Ohio River. Daily examinations of the water of Ohio River were made from October 16, 1895, to July 24, 1897, the reports of which will not be given here in full, but attention will be directed to several important determinations.

Relative to the drainage area and general hydrographic conditions Mr. Fuller writes as follows:

> The water of the Ohio River at Louisville varies widely from time to time in its composition. This variation is caused by a number of factors, among which are the following:
>
> 1. The size and varying geological formation of the watershed.
> 2. The number of comparatively large tributaries which drain areas of distinctly unlike geological character.
> 3. The amount of precipitation (rain and snow).
> 4. The distribution of the precipitation over the watershed.
> 5. The condition of the soil at the beginning of heavy rain storms.
> 6. The amount and rate of precipitation during single storms.
> 7. The stage of the river.
> 8. The velocity of flow of the river.
> 9. Agitation of the water in the river due to wind storms, etc.
>
> The total population resident on this watershed above Louisville is estimated at 4,500,000, of which 1,575,000 is contained in 220 towns and cities, according to the census of 1890, increased 15 per cent for the six years of the present decade. The nearest city discharging sewage into the water which passes this pumping station is Madison, Ind., situated about 50 miles above Louisville, with a population of about 12,000. The next city is Frankfort, Ky., situated on the Kentucky River, 67 miles from its mouth. This city has a population of about 10,000. The Kentucky River joins the Ohio about 57 miles above Louisville. The nearest large center of population discharging sewage into this water supply is at Cin-

cinnati, Ohio. Opposite this city are the cities of Newport and Covington, Ky. Their aggregate population (three cities) is about 420,000, and they are distant above Louisville about 150 miles by river.

The rises and floods in the Ohio River, with their associated factors, produce wide and rapidly changing variations in the composition of the river water. Owing to the fact that the composition of the river water is a prominent factor in the cost of purification, analyses were made practically every day during these tests of the water before its application to the systems of purification. Before giving attention to the results of analyses, however, the question of frequency and depth of freshets or floods is to be considered.[a]

TABLE 147.—*Amount of carbonic acid gas (carbon dioxide) dissolved in the Ohio River water at Louisville.*

[Parts per million.]

Date.	Carbonic acid gas.	Date.	Carbonic acid gas.	Date.	Carbonic acid gas.	Date.	Carbonic acid gas.
1896.		1897.		1897.		1897.	
June 18	[b]30.8	Mar. 24	44.9	May 7	57.4	June 18	82.7
22	[b]26.4	25	41.9	8	110.6	19	106.3
24	[b]27.7	26	36.5	9	66.7	20	100.3
27	[b]29.7	27	47.0	10	72.1	21	100.3
July 3	[b]30.6	29	56.6	13	65.2	22	100.3
8	[b]21.1	30	80.0	14	76.6	23	107.4
Nov. 28	83.0	Apr. 1	53.6	15	50.8	24	100.3
Dec. 10	98.0	2	59.0	18	67.3	25	105.6
1897.		3	53.5	19	71.8	26	113.7
Feb. 16	80.4	7	79.6	21	88.7	27	120.0
Mar. 2	63.4	8	46.0	22	95.9	28	92.1
3	59.0	9	91.0	23	94.3	30	105.9
4	67.8	10	80.0	26	80.2	July 1	93.9
5	49.3	12	65.0	27	80.0	2	75.3
6	47.6	13	44.0	28	107.3	3	73.1
7	51.4	14	75.7	29	101.6	6	100.4
11	99.5	15	88.3	June 1	66.6	7	106.1
12	88.0	16	50.2	2	90.5	8	99.9
13	122.4	21	41.2	4	82.7	12	71.8
15	45.8	22	42.7	7	89.0	15	47.0
16	33.4	23	43.0	10	133.0	16	28.8
19	38.8	25	55.0	11	107.6	17	49.4
20	42.6	27	94.9	15	98.8		
22	46.4	29	85.9	16	103.3		
23	40.4	May 4	86.8	17	107.6		

[a] Report on the investigations into the purification of the Ohio River water at Louisville, Ky., made to the president and directors of the Louisville Water Company by George W. Fuller, 1898.

[b] The results of June and July, 1896, were obtained by the Pettenkoffer method, without the Trillich modification, and are probably much too low

The normal hardness or amount of incrusting constituents in the Ohio River water is set forth in the following table:

TABLE 148.—*Normal hardness of water of Ohio River at Louisville.*

[Parts per million.]

Date.	Normal hardness.	Date.	Normal hardness.	Date.	Normal hardness.	Date.	Normal hardness.
1895.		1897.		1897.		1897.	
Dec. 9–11	43.9	Mar. 15	14.0	Apr. 20–21	15.5	May 28–29	16.8
1896.		16	20.5	21–22	17.5	31	.....
May 6	43.0	17	24.6	22	12.0	June 1	17.0
14	33.8	18	36.7	22–23	14.6	2–3	17.6
22	40.1	19	16.7	23–24	14.3	4–5	23.5
29	41.1	20	22.0	27	12.7	7–8	22.5
June 11	44.0	22	12.0	28	17.0	9–10	23.8
18	30.0	23	9.6	29	32.0	11–12	28.8
July 30	35.0	24	10.8	29–30	21.7	21	28.8
1897.		25	10.0	30	.....	22	31.0
Feb. 17	18.7	26	13.9	May 1	20.0	23	27.8
22	24.7	29	12.8	4	23.0	24	21.9
23	17.2	30	33.3	5	17.0	25	19.0
24	21.2	Apr. 1	29.1	6–7	15.5	27	17.5
25	16.1	2–3	18.2	8–9	15.8	28	25.5
26	8.0	3–4	11.0	13	16.1	29–30	20.0
Mar. 1	15.8	5	29.9	14	23.2	July 2	20.0
2	10.0	6	23.4	15	11.3	6	20.9
3	8.0	6–7	30.0	17–19	9.0	7	27.0
4	12.0	8	19.8	19–20	10.8	9–10	11.0
5	25.3	9	14.2	21	11.9	12–13	12.0
6	34.6	9–10	13.3	21–23	15.9	14–15	14.8
7	16.0	11	9.0	23–24	10.2	16	14.0
9	23.4	12	12.7	25	20.2	17–18	12.3
10	17.9	13–14	16.0	25–26	14.5	19–20	24.2
11	30.0	14–15	20.0	27	16.7	21–22	24.2
12	33.0	15–16	18.1	27–28	19.3	23–24	43.8

An interesting investigation into the amount and corrosive effect of dissolved carbon dioxide in the river water brought out the fact that such determinations are of more importance than had been previously supposed. The observation is made in Mr. Fuller's report that at times the weight of the dissolved carbon dioxide in the river water equals and even exceeds the weight of all dissolved solids. The amount of carbon dioxide found in the water at each examination is set down in Table 147.

SUMMARY.

In the foregoing pages we have reviewed the important and readily available records of water examinations which have been carried on in this country, except those now being prosecuted in connection with the Chicago Drainage Canal and Illinois River. It is apparent from this review that the pollution of natural waters follows social municipal progress. Those rivers which remain in their normal condition are situated in areas that have not been penetrated to any extent by the growth of American institutions. Nearly all important streams have been damaged and their normal resources diminished. The question may be asked: Is not the damage done to these streams by the sewage of cities and by industrial plants merely a part of the compensation which we should willingly pay for the advantages that we have gained through the establishment of those polluting influences? Undoubtely, to a certain degree; but the fact still remains that in most cases when such damage is carried beyond a certain point it must be regarded as needless and unwarranted.

Water pollution is inevitable wherever the human race is clustered together in large numbers, but by the application of the methods of sewage disposal which modern science has made available, and by the exercise of an ordinary amount of municipal decency, such pollution can be so restricted that it will result in the destruction of only one or two of the resources which are vested in natural waters.

There is no doubt that the run-off water from a thickly settled country is likely to be dangerous for domestic uses unless it is filtered, and the current methods of sewage disposal, while theoretically perfect, are practically not sufficiently so to warrant us in using the so-called purified effluents as we would use the run-off from an uninhabited region. Yet, if proper precautions are taken and the same attention is paid to sewage disposal that is ordinarily given to other departments of municipal affairs, every community will be the richer and the tremendous waste of natural resources which is now taking place will ultimately be restricted to that which is necessary.

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Subject.

Leighton, Marshall Ora.

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192 p., 1 l. 17 fig. 23½cm. (U. S. Geological survey. Water-supply and irrigation paper no. 79.)

Subject series L, Quality of water, 5.

Series.

U. S. Geological survey.

Water-supply and irrigation papers

no. 79. Leighton, M. O. Normal and polluted waters in northeastern United States. 1903.

Reference.

U. S. Dept. of the Interior.

see also

U. S. Geological survey.

Water-Supply and Irrigation Paper No. 80 Series M, General Hydrographic Investigations, 4

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

THE

RELATION OF RAINFALL TO RUN-OFF

BY

GEORGE W. RAFTER

WASHINGTON
GOVERNMENT PRINTING OFFICE
1903

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THE RELATION OF RAINFALL TO RUN-OFF.

By GEORGE W. RAFTER.

INTRODUCTION.

The run-off of a stream is influenced by many complex conditions—as, for instance, amount of rainfall and its intensity, nature of soil, slope of surface, and area and configuration of catchment basin. It is also influenced by geologic structure, forests, wind, force of vapor pressure, and other elements. Data are still lacking for a really satisfactory discussion of the question, although they have accumulated so rapidly during the last few years that many conservative conclusions can be drawn which may be accepted as substantially true.

The subject has been discussed in the Transactions of the American Society of Civil Engineers by Messrs. Herschel, Fteley, FitzGerald, Babb, and others in a series of able papers,[a] but no one of these exhibits a complete view.

It has also been discussed in other publications, but so far as known to the writer the Transactions of the American Society contain the most complete discussion of the subject that can be found in English engineering literature.

As a result of many years' study of the problem indicated by the title of this paper the writer has come to the conclusion that no general formula is likely to be found expressing accurately the relation of rainfall to the run-off of streams, for streams vary widely in their behavior, and when they do agree the agreement is usually accidental. As a general proposition we may say that every stream is a law unto itself.

The final formula of run-off for a given stream, therefore, will differ in some particulars from that for every other, except that there may be accidental resemblances as regards slope, shape of catchment area, or some other peculiarity. It is, however, true that an empirical formula may be made for certain classes of streams which will give approximately the run-off for a series of years.

[a] See Trans., Vol. X, p. 225; Vol. XXVII, p. 253; and Vol. XXVIII, p. 323.

RAINFALL.

CAUSE OF RAINFALL.

The cause of rainfall has been discussed by Mr. Velschow in the Transactions of the American Society of Civil Engineers.[a] This paper may be referred to for a very good discussion of the subject.

The subject is also very ably discussed by Alfred J. Henry in one of the Weather Bureau reports.[b] Mr. Henry remarks that the theories of rainfall given in books of twenty or thirty years ago are not now wholly accepted. Still there is one simple principle upon which no disagreement exists—that in order to produce rain the temperature of the air must be suddenly cooled below the dew point. When the air is thus cooled a portion of the vapor is changed to the liquid state and the particles thus formed may float away with the wind or they may increase in size and fall to the ground by virtue of gravity. Whether the condensation results simply in cloud, or whether rain falls, depends on the magnitude of the temperature changes taking place in the air mass.

The precise manner in which air is cooled to produce rain, whether by contact or by mixing, is not clearly apprehended. Cooling by expansion, as air ascends, is one of the most effective causes of rainfall. The ascensional movement is brought about in several ways, probably the most important of which is circulation of air in cyclonic storms, by a radial inflow from all sides and an ascensional movement in the center. A very large percentage of the rain of the United States is precipitated in connection with the passage of storms of this class.[c]

Mr. Henry discusses the precipitation of the United States under the following topics: (1) The statistics used and their accuracy; (2) Geographic distribution and annual allowance; (3) Monthly distribution by districts and types; (4) The precipitation of the crop-growing season; (5) Secular variations; (6) Details of the precipitation by geographic districts; and (7) Excessive precipitation.

The chapter on "Excessive precipitation" is probably, from an engineering point of view, the most important. Mr. Henry states that in 1888 attention was first directed to the importance of statistics of excessive rainfall. At the present time the Monthly Weather Review publishes a table of maximum rainfalls in five and ten minute and one hour periods, etc.

Table No. VIII of Mr. Henry's paper gives details of excessive rainfall at Washington, Savannah, and St. Louis, and Table No. IX gives maximum intensity of rainfall for periods of five, ten, and sixty min-

[a] The cause of rain and the structure of the atmosphere, by Franz A. Velschow: Trans. Am. Soc. Civil Eng., Vol. XXXIII, 1890, p. 303.

[b] Rainfall of the United States, by Alfred J. Henry, chief of division: Ann. Rept. Weather Bureau, 1896-97, p. 317.

[c] Abstracted from Mr. Henry's paper.

utes at the Weather Bureau stations equipped with self-registering gages, compiled from all available records. Inasmuch as this paper may be readily referred to in the publication cited, further detail is omitted.

MEASUREMENT OF RAINFALL.

The subject, "How close may rainfall be measured?" has been fully discussed by Prof. Cleveland Abbe.[a] Professor Abbe states that the influence of altitude was first brought to the attention of the learned world by Heberden who, in 1769, in a memoir in the Transactions of the Royal Society of London, stated that a gage on Westminster Abbey, over 150 feet above the ground, caught less than half as much as a gage at the ground.

Profs. Alexander D. Bache and Joseph Henry, and Mr. Desmond FitzGerald have studied the question extensively in this country. Mr. FitzGerald's results may be found in the Journal of the Association of Engineering Societies for August, 1884.[b]

Mr. FitzGerald kept two gages, one at a height of 2 feet 6 inches above the level of the ground, and the second at a distance of 150 feet from the first, and at an elevation of 20 feet 4 inches above the lower gage. Both gages were 14.85 inches in diameter. These gages were located at Chestnut Hill reservoir, in the city of Boston, but the observations for wind velocity were taken from the Signal Service observations, 5 miles distant. With only five exceptions during the five-year period, the upper gage delivered materially less water than the ground gage, the average difference being 10.6 per cent for the whole period. But snowfalls and mixtures of snow and rain are not included in the table of data given in the paper.

The results recorded by Professor Abbe are somewhat more extensive than those presented by Mr. FitzGerald, though Mr. FitzGerald states in his paper that he has prepared a series of experiments with nine gages and a self-recording anemometer, from which in the course of time some more definite results may be reached. So far as the writer knows, this second series of observations has not been published.

In order to show how the catch of rainfall diminishes with height of the gage, Professor Abbe gives in his Table No. IV the results of observations at different places. These range from 90 per cent of a gage at the ground to 47 per cent. In Tables Nos. I, II, and III, Professor Abbe also gives the result of various gages, which gave 52 to 7 per cent less of rainfall, and from 80 to 16 per cent less of snowfall, than gages at the ground. Professor Abbe remarks that these tables show conclusively the large influence of wind on the catch of rain, but show

[a] Determination of the true amount of precipitation and its bearing on theories of forest influences, by Cleveland Abbe: Appendix I of Bulletin No. 7, Forest Influences; Forestry Division, United States Department of Agriculture.

[b] Does the wind cause the diminished amount of rain collected in elevated rain gages? By Desmond FitzGerald: Jour. Assoc. Engineering Societies, Vol. III, No. 10 (August, 1884).

nothing of its influence on the catch of snow. As an observational method of obtaining the true rainfall from gage readings, Professor Abbe suggests the following as offering a fair approximation:

If the present gage has been standing in an open field at a few feet elevation, place two or more similar gages near it, and similarly located as far as obstacles are concerned, except only that one of these is to be decidedly lower than the old one and the other decidedly higher. From a comparison of the simultaneous records of any two gages and their altitudes, we should for each separate rainfall, rather than for the monthly and annual sums, deduce the normal rainfall by the solution of two or more equations of the form:

Observe catch of gage $= (1 - x \text{ altitude}) \times (\text{desired catch of normal pit gage})$. (1)

Where x is the unknown special coefficient of deficiency due to wind at that altitude—that is to say, having two gage catches, c_1 and c_2 for the two altitudes. H_1 and H_2—we obtain the true rainfall (R) by the formulas:

$$c_1 = (1 - x\sqrt{H_1})\ R; \text{ and} \tag{2}$$

$$c_2 = (1 - x\sqrt{H_2})\ R. \tag{3}$$

whence,

$$R = \frac{c_1\sqrt{H_2} - c_2\sqrt{H_1}}{\sqrt{H_2} - \sqrt{H_1}} = c_1 + \frac{1}{\sqrt{\frac{H_2}{H_1}} - 1}(c_1 - c) = c_1 + n(c_1 - c_2). \tag{4}$$

If c_1 and H_1 relate to the lower gage, we shall generally have $c_1 > c_2$ and $H_1 < H_2$, and the coefficient n will be a positive fraction, for value of which, for such combinations as may easily occur in practice, a table is given in the paper.

It is evident then, without special discussion, that nearly all rainfall measurements thus far made in the United States are only approximations, and that while they remain in this state to carry them out to more than one decimal place is an unnecessary refinement.

DETERMINATION OF MINIMUM RAINFALL.

The writer has spent considerable time in an attempt to determine about what the minimum rainfall at any particular station may be expected to be; or, rather, he has endeavored to ascertain the relation between the minimum rainfall and the maximum. In the course of this quest he has examined practically all the records in the State of New York, as well as many records in New Jersey, Pennsylvania, Michigan, Illinois, Nebraska, Colorado, and Wyoming, as well as in Canada. As a general rule, to which there are some exceptions, the minimum rainfall may be placed at about one-half of the maximum. That is, if the maximum rainfall at a given station is about 50 inches, the minimum will be in the vicinity of 20 to 25 inches. In some cases the minimum will be not more than one-third of the maximum, or even somewhat less than one-third; occasionally, not more than one-quarter. It is not intended, however, to lay this down as an absolutely universal rule, but rather, for the present, as a somewhat imperfect guide. As a further rough guide it remains to point out that in case a given record does not conform substantially to the foregoing it may be assumed that either the minimum or the maximum,

as the case may be, is still to occur. Near the seacoast, where the supply of moisture in the air is more nearly constant, there is less variation than in the interior, and the rule that the maximum is double the minimum is more generally true. This proposition is also generally true as regards English meteorology.

IS RAINFALL INCREASING?

This question has been discussed by Prof. Mark W. Harrington,[a] who, however, reached no very definite conclusion, although he is disposed to answer it in the negative. The method of discussion followed was to reduce the annual rainfalls to a series of means of each five years. These means were entered on a succession of maps, five years apart in time, and on these maps was drawn the line of 40 inches of annual rainfall. The question to be determined is, as we draw this line for each five-year mean, Does it change its position in any regular and systematic way?

An examination of the detail shows that while these lines are subject to limited fluctuations there are no uniform or systematic fluctuations. The line of equal rainfall for 1861–1865 occupied nearly the same position as the line for 1886–1890. The variations are sometimes extensive, but without systematic progress. Professor Harrington therefore concludes that with the data at hand there is not sufficient evidence of systematic fluctuation of the rainfall.

RELATION OF RAINFALL TO ALTITUDE.

This matter has been referred to in a discussion of Mr. Noble's paper on Gagings of Cedar River, Washington,[b] where the statement has been made that in the State of New York the rainfall records show both increase and diminution of precipitation with increase of altitude. The Hudson River catchment area shows a higher precipitation at the mouth of the river than it does at its source in the Adirondack Mountains, while the Genesee River shows the opposite, namely, higher precipitation at its source than at its mouth.

According to a table of average monthly, annual, and seasonal precipitation in Mr. Turner's monograph on the climate of New York State[c] it appears that the coast region, which includes Block Island, East Hampton, Setauket, Fort Columbus, New York City, Mount Pleasant, Tarrytown, White Plains, Croton dam, and North Salem, has an average annual precipitation of 44.93 inches. With the exception of Block Island these stations are all in New York and not far

[a] Rainfall and snow of the United States, compiled to the end of 1891, with annual, seasonal, monthly, and other charts, by Mark W. Harrington: Bulletin C, Weather Bureau, U. S. Dept. of Agriculture.

[b] Trans. Am. Soc. Civil Eng., Vol. XLI, pp. 1–26.

[c] The climate of New York State, by E. T. Turner, C. E., late meteorologist of the New York weather bureau: Fifth Ann. Rept. New York Weather Bureau, 1893. Reprinted in Eighth Ann. Rept. of the bureau, 1896.

from the coast, and they range in elevation above tide water from 16 feet at East Hampton to 361 feet at North Salem. The average elevation of the coast region is 132 feet. The records vary in length from 7 years to 49 years, with a total of 195 years. Five of the stations are in Westchester County.

As given by Mr. Turner, the northern plateau includes Constableville, Lowville, Fairfield, Johnstown, Pottersville, Elizabethtown, Keene Valley, and Dannemora, in the counties of Lewis, Herkimer, Warren, Essex, and Clinton. According to the table the average annual precipitation at these places is 38.97 inches. The elevation of the stations above tide ranges from 600 feet at Elizabethtown to 1,356 feet at Dannemora, with an average elevation of 973 feet. The records vary in length from 4 to 22 years, with a total of 73 years.

Again, the western plateau, which includes stations in Cattaraugus, Wyoming, Allegany, Steuben, Livingston, and Chemung counties, has an average elevation above tide of 1,307 feet, ranging from 1,950 feet to 525 feet, and has an average annual precipitation of 35.58 inches, while the Hudson Valley, which includes stations in Putnam, Orange, Dutchess, Ulster, Columbia, Albany, Rensselaer, and Washington counties, has an average elevation of 230 feet above tide, with an average annual precipitation of 38.46 inches. The records range from 9 years to 65 years, with a total of 277 years.

The Great Lakes region, with an average elevation of 494 feet, has an average annual precipitation of 35.17 inches, while the central lake region, with an average elevation of 690 feet, has an average annual precipitation of 43.41 inches.

Mr. Turner's table is based on a calendar year, from January to December, inclusive. Further data may be obtained from this excellent table.

In Table No. 24 of the Upper Hudson Storage Surveys Report for 1896 there is given the mean precipitation of the Upper Hudson catchment area. The stations therein included are: Albany, 1825–1895, 71 years; Glens Falls, 1879–1895, 17 years; Keene Valley, 1879–1895, 17 years; western Massachusetts, 1887–1895, 9 years; northern plateau, 1889–1895, 6½ years; Lowville Academy, 1827–1848, 22 years; Johnstown Academy, 1828–1845, 18 years; Cambridge Academy, 1827–1839, 13 years; Fairfield Academy, 1828–1849, 22 years; Granville Academy, 1835–1849, 15 years. Assuming the northern plateau as a unit the total number of years is 199½, and the mean of all is 37.4 inches. A reference to the rainfall map in the report of the United States Board of Engineers on Deep Waterways will show that this is necessarily an approximation, because of great lack of stations in the interior of this region.

As regards the catchment area of the Upper Genesee River, there is a very decided increase in rainfall as one goes toward the source. For the years 1889–1896, inclusive, the rainfall in the upper area of this stream was 42.19 inches, while at Rochester for the same years

it was 35.64 inches. This statement is especially interesting, because there seems to be a well-marked line dividing the smaller rainfalls of the lower area from the higher rainfalls of the upper. At Hemlock Lake, Avon, and Mount Morris the rainfalls are all low, the average at Hemlock Lake from 1876–1895, inclusive, being 27.56 inches. In 1880 it was 21.99 inches; in 1879, 22.16 inches, and in 1881 only 24.36 inches. We have here three years of exceedingly low rainfall, in which the run-off must have also been very low. In 1895 the rainfall at Hemlock Lake was only 18.58 inches. The average precipitation at Avon and Mount Morris from 1891 to 1896, inclusive, was 30.12 inches. In 1895 it was only 25.05 inches. The following are stations at which it was much higher for the years 1891 to 1895, inclusive: Leroy, 45.25 inches, and Arcade, 41.60 inches.

The statements of precipitation in Genesee River catchment area are all based on a water year, December to November, inclusive.

The following are from Russell's Meteorology,[a] illustrating Atlantic coast rainfalls, and are the averages derived from observations extending from 1870 to 1888. The rainfalls are stated to be fairly representative for large districts of country around the places.

At Jacksonville the weather bureau office is at an elevation above tide of 43 feet, while the average annual rainfall is 57.1 inches. At Norfolk the elevation of weather bureau is 57 feet above tide, and the average rainfall is 51.7 inches. At Boston the weather bureau office is 125 feet above tide, and the average rainfall is 46.8 inches.

The following illustrate the change as one goes north through the Mississippi Valley: At New Orleans the weather bureau office is 54 feet above tide, the average rainfall 62.6 inches; at St. Louis, weather bureau office 567 feet above tide, average rainfall 37.8 inches; at St. Paul, weather bureau office 850 feet above tide, average rainfall 28.9 inches.

The following illustrate the Rocky Mountain region: At Fort Grant, Ariz., elevation of weather bureau 4,833 feet, average rainfall 15.8 inches; at Denver, elevation of weather bureau 5,300 feet, average rainfall 14.7 inches; at Fort Benton, Mont., elevation 2,565 feet, average rainfall 13.2 inches.

The following illustrate the Pacific coast region: At Portland, elevation of weather bureau office is 157 feet, average rainfall 50.3 inches; San Francisco, elevation 153 feet, average rainfall 23 inches; San Diego, elevation 69 feet, average rainfall 10.2 inches.

These figures abundantly support the proposition that in the United States the rule of increased precipitation with higher altitude is by no means universal. The writer can not say positively, because he has not examined the vast number of records with reference to this point, but he thinks it quite possible that the reverse is more nearly true. That is, owing to distance from the ocean, prevailing direction

[a] Meteorology, by Thomas Russell, U. S. Asst. Engineer.

of wind, and other causes, it is probable that for the entire country precipitation decreases with higher altitude rather than increases.

The decision of this question will depend to some extent upon the steepness of ascent. Thus on Mount Washington, which is projected into the air far above the surrounding mountains, the rainfall is about 83 inches. In other cases, where the ascent is gradual, no increase is apparent. The same is also frequently true of sharp ascents. On Longs Peak, in Colorado (elevation 14,271 feet), the rainfall in 1899 was 16.7 inches.

Morever, the writer has mostly avoided comparatively small differences in rainfall—those not exceeding 2 to 2.5 inches. In such cases the difference is too small to be any certain guide. Especially is this true in the case of the northern plateau, where there is still a great lack of stations. The differences between high altitudes and low should be as much as 5 or 6 inches. Again, whether the excess rainfall occcurs in the winter or summer months must be taken into account. If it occurs in the summer, even 3 inches of rainfall may not make more than 0.1 or 0.2 inch in the stream. Rainfall and run-off observations are not yet, nor are they likely to ever be, definite enough to take into account an annual difference of much less than about 1 to 1.5 inches. Again, the writer has ceased to be excessively particular about the total of the annual rainfall. Assuming some considerable length of record, small errors have relatively slight effect. This matter is referred to here because nearly all rainfall records—at any rate in the United States—have more or less error in them, and while it is desirable to have records as reliable as possible, a few errors do not affect a record very seriously. It is nevertheless very desirable to know the history of the record in order to insure the degree of confidence to be placed in it.

MAP OF AVERAGE RAINFALL IN THE STATE OF NEW YORK.

On Pl. XCVIII of the Report to the United States Board of Engineers on Deep Waterways, the writer has given the average rainfall at a large number of stations throughout the State of New York. When this map was prepared considerable time was expended in drawing lines of equal rainfall upon it, but so many discrepancies appeared that it was finally concluded, for the present, that it should be allowed to stand without such lines. The only way these contours could be drawn with any satisfaction was to omit stations which conflicted too much therewith. This, the writer did not feel justified in doing. The observations are not extensive enough to enable one to draw these lines.

DIVISION OF RAINFALL AND RUN-OFF INTO STORAGE, GROWING, AND REPLENISHING PERIODS.

The writer has found it very convenient to divide rainfall and run-off records into the three periods, those of storage, growing, and

replenishing, with a water year beginning December 1 and ending November 30. The storage period includes the months from December to May, inclusive, during which the evaporation and absorption by plants are relatively slight, and a very large proportion of the rainfall appears in the streams.

The growing period of active vegetation, when evaporation and absorption by plants are most notable. During this period, frequently not more than 0.1 of the rainfall appears in the streams, and sometimes not more than 0.05 or even less. Ground water tends to become lower and lower during this period, unless the rainfall is much higher than the average.

In the replenishing period, September to November, inclusive, with the normal rainfall, ground water tends to recover, and the run-off is larger than in the preceding period. This period is replenishing in this, that there is a tendency to return to normal conditions.

No hard and fast rule, however, can be laid down as to the beginning and ending of these periods. In some years the beginning of the water year should be placed at November 1, instead of December 1, while in others the storage period may end with April. Very often, one period runs into another, but after considerable study the foregoing divisions have been accepted as, on the whole, best representing all the conditions. In England many hydrologists begin the water year with September 1 as best suiting the conditions. The same thing has been done by the Philadelphia water department in tabulating the data and by Neshaminy, Perkiomen, Tohickon, and Wissahickon creeks on Schuylkill River.

The great advantage of dividing records into these periods is as follows: Since evaporation and plant absorption are light during the months of the storage period, it follows to a great degree that the amount of water which can be stored is exhibited by the rainfall of the storage months. Realizing this fact, it has been the writer's habit for several years, in storage projects, to first tabulate rainfall in the manner indicated. Such procedure has the advantage that it leads one away from the contemplation of mere detail. There is a positive disadvantage in considering the monthly quantities, for which there is no compensation. The division into the three periods exhibits the more important characteristics without overburdening the mind. It is believed that a considerable advance on ordinary practice has been made by proceeding in the manner stated.

LENGTH OF TIME REQUIRED TO MAKE GOOD A SERIES OF RAINFALL RECORDS.

This question is partially answered in the writer's second report on the Upper Hudson Storage Surveys, for 1896, by a short analysis

of a paper by Alexander R. Binnie, member of the Institution of Civil Engineers.[a]

One of the important problems worked out by Mr. Binnie is an answer to this question: What is the least number of years of which the continuous record, when the average rainfall has been determined, will not be materially affected, so far as the value of the mean is concerned, even if the record be extended by a greater number of years' observations? Also, What is the probable accuracy of any record the length of which is less than that necessary to give an average which will not be materially altered when the record is extended?

Space will not be taken to show Mr. Binnie's views in detail, for which reference may be made to the abstract in the second Hudson report, or, for the complete views, to the paper in the Proceedings of the Institution of Civil Engineers, but assuming that the observations are properly made it is stated that "dependence can be placed on any good record of thirty-five years' duration to give a mean rainfall correct within 2 per cent of the truth."

Further, it can be stated that for records from twenty years to thirty-five years in length, the error may be expected to vary from 3.25 per cent down to 2 per cent, and that for the shorter periods of five, ten, and fifteen years, the probable extreme deviation from the mean would be 15 per cent, 8.25 per cent, and 4.75 per cent, respectively.

A twenty years' record, therefore, may be expected to show an error of 3.24 per cent. This is about as close as rainfall records in this country can be expected to agree, as comparatively few are much beyond twenty years in length.

In his paper on the Rainfall of the United States, Mr. Henry has examined this question, using long records at New Bedford, St. Louis, Philadelphia, Cincinnati, and other places. The rainfall has been measured at New Bedford for 83 consecutive years, and at St. Louis for 60 years. For a 10-year period Mr. Henry found the following variations from the normal: At New Bedford + 16 per cent and − 11 per cent; at Cincinnati, + 20 per cent and − 17 per cent; at St. Louis, + 17 per cent and − 13 per cent; at Fort Leavenworth, + 16 per cent and − 18 per cent; and at San Francisco, + 9 per cent and − 10 per cent. For a 25-year period, it was found that the extreme variation was 10 per cent, both at St. Louis and New Bedford. Mr. Henry reached the conclusion that at least 35 to 40 years' observations are required to obtain a result that will not depart more than ± 5 per cent from the true normal. The average variation of a 35-year period was found to be ± 5 per cent, and for a 40-year period ± 3 per cent.

This preliminary study indicates slightly more range than was found

[a] On mean or average rainfall and the fluctuations to which it is subject, by Alexander R. Binnie, Inst. C. E.: Proc. Inst. C. E., Vol. CIX (1892), pp. 89–172.

by Mr. Binnie, although it may be remembered that the observations of the latter are far more extensive than Mr. Henry's.

Again, since the run-off is a function of the rainfall, it follows that it must be affected in some degree in a similar manner. As to just the relation, so far as known, very few computations have been made. Indeed, very few run-off tabulations are extant which are long enough to settle this question. It is clearly, therefore, very difficult to solve definitely so abstruse a problem as that of the extent to which forests affect rainfall. All solutions are necessarily, and will be for some time to come, tentative in their character.

RUN-OFF.

THE LAWS OF STREAM FLOW.

A general statement of these laws from Mr. Vermeule is as follows:

The waters of the earth are taken up by the process which we call evaporation and formed into clouds, to be again precipitated to earth in the form of rain or snow. Of the water which falls upon the basin of a stream, a portion is evaporated directly by the sun; another large portion is taken up by plant growth and mostly transpired in vapor; still another portion, large in winter but very small in summer, finds its way over the surface directly into the stream, forming surface or flood flows: finally, another part sinks into the ground, to replenish the great reservoir from which plants are fed and stream flows maintained during the periods of slight rainfall, for the rainfall is frequently, for months together, much less than the combined demands of evaporation, plant growth, and stream flow. These demands are inexorable, and it is the ground storage which is called upon to supply them when rain fails to do so.

All of these ways of disposing of the rain which falls upon the earth may be classed as either evaporation or stream flow. Evaporation we make to include direct evaporation from the surface of the earth, or from water surfaces, and also the water taken up by vegetation, most of which is transpired as vapor, but a portion of which is taken permanently into the organisms of the plants. Stream flow includes the water which passes directly over the sur ace to the stream, and also that which is temporarily absorbed by the earth to be slowly discharged into the streams. A portion, usually extremely small, passes downward into the earth and appears neither as evaporation nor as stream flow. It is usually too small to be considered, and we may for our purposes assume that all of the rain which falls upon a given watershed and does not go off as stream flow is evaporated, using the latter word in the broadened sense which we have above described.

Probably one very important effect of forests is that upon the ground-water flow of streams. The stream with a catchment area wholly or largely in forests will show, without exception, a much better ground flow than one with the area denuded of forests. Neshaminy and Tohickon creeks may be cited as streams with the smallest amount of forest and the lowest curve of ground-water flow. Possibly this is not entirely due to forests, but it may be assumed that they bear some relation to the result.[a]

[a] Examples of ground-water curves for the chief streams herein considered may be found in Mr. Vermeule's report on the flow of streams, etc., in Final Rept. State Geologist of New Jersey, Vol. III. Trenton, 1894.

UNITS OF MEASUREMENT.

Clemens Herschel, member American Society Civil Engineers, in his paper on Measuring Water,[a] has defined the essential elements of this question in the following terms:

> For most purposes the unit of volume, when using English measures, has been agreed upon in favor of the cubic foot, and the nations of the earth being fortunately agreed upon their measures of time, have settled upon one second of time as the unit to use in measuring water. Nevertheless, the million United States gallons in twenty-four hours has become a standard for city water supply practice in the United States, and an acre in area covered an inch or a foot deep in a month or in a year is used in irrigation practice. But I would warn all engineers to be very slow to add to the number of such standards of measure for flowing water, and to abstain from and frown down such absurd standards as cubic yards per day, or tons weight of water per day, or even cubic feet per minute (instead of second), and other incongruities. * * * As exercises in the art of arithmetic for children such computations may have value, but in the work of civil engineers they become a stumbling block to an advance of knowledge, and while unduly magnifying the unessentials they indicate a deplorable lack of appreciation of the essentials of the art of the civil engineer.
>
> Cubic measures do well enough for the contents of vessels, or as we may express it, for dealing with the science of hydrostatics. But so soon as the water to be measured is in motion, or so soon as the science of hydraulics has been entered upon, we must get clearly in our minds the idea of rates of flow, or of a procession of such cubic volumes passing a given point in a certain unit of time, as of a flow of so many cubic feet per second.

Very little can be added to what Mr. Herschel has here said. It is a clear exposition of the whole subject. Such units as cubic feet per day and cubic miles have clearly no place in a modern paper on hydrology.

The unit of inches on the catchment area may, however, be pointed out as an exception to the foregoing general rule. This unit is exceedingly convenient because it admits of expressing rainfall and run-off in the same unit and without reference to the area. It brings out a number of relations not otherwise easily shown, as will be exhibited in discussing the tables accompanying this paper.

MINIMUM FLOW OF STREAMS.

Very little can be added to our knowledge of the minimum flow of streams beyond what has already been stated in Water Supply and Irrigation Paper No. 24, Water Resources of the State of New York, Part I, which applies particularly to streams in the State of New York. Summarizing the information there given, we may say that for streams issuing from regions of heavy, compact soil, mostly deforested, the extreme minimums are likely to run as low as 0.1 of a cubic foot per square mile per second. They may even in an extreme drought go as low as 0.05 of a cubic foot per square mile per second.

[a] Measuring Water, by Clemens Herschel; An address to the students of Rensselaer Polytechnic Institute, Troy, N. Y.

Oswego River, by reason of large lake pondage, has a minimum flow of about 0.3 of a cubic foot per square mile per second. For a similar reason the Upper Hudson will not usually go less than 0.3 of a cubic foot per square mile per second, although in the summer of 1899 it probably did not exceed 0.2 of a cubic foot per square mile per second. This, however, was unusual. The streams of Long Island, issuing from sand plains, may be expected to give minimum flows of from 0.5 to 0.6 of a cubic foot per square mile per second. The streams of the northern part of New York, issuing from denser forests than the others, also give minimum yields somewhat in excess of 0.3 of a cubic foot per square mile per second. The streams tributary to Mohawk River, on the south side of the valley, will give minimum flows of not more than one-half of what the streams tributary on the north side give. As to the streams of the far West, many of them are frequently dry for several months at a time. A typical stream of this character is the Platte River, with a catchment area at Columbus, Nebr., of 56,867 square miles.[a]

CHARACTERISTICS OF THE MINIMUM RUN-OFF.

Since the rainfall varies so widely, the run-off, which is a function of the rainfall, will also vary widely. On the Hudson River the maximum run-off of 33.08 inches, with a rainfall of 53.87 inches, occurred in 1892. The minimum, with a run-off of 17.46 inches and a rainfall of 36.37 inches, occurred in 1895. On the Genesee River the observed maximum rainfall of 47.79 inches, with a run-off of 19.38 inches, occurred in 1894.[b] The minimum rainfall of 31 inches, with a minimum run-off of 6.67 inches, occurred in 1895. These figures of rainfall indicate that either the extreme maximum or the extreme minimum rainfall has not yet occurred on the catchment area of this stream.

On the Muskingum River the maximum rainfall thus far observed is 56.97 inches, with a maximum run-off of 26.84 inches, which occurred in 1890. The observed minimum rainfall of 29.84 inches, with the corresponding minimum run-off of 4.9 inches, occurred in 1895. It is also doubtful if either the extreme maximum or the extreme minimum rainfall has been yet observed on the catchment area of this stream. As to whether the rainfall will go lower there is no certain way of determining. Moreover, 4.9 inches seems a very low run-off—and the run-off is not likely to be less than this figure. However, the run-off in any year depends very largely on the rainfall of the months from

[a] For an extensive list of streams of which the maximum and minimum flows are given, the following may be consulted:

(1) Water Power of the United States, Tenth Census, Vol. I, pp. XXVIII and XXIX.

(2) Twentieth Ann. Rept. U. S. Geol. Survey, Part IV, Hydrography, pp. 46-63.

(3) Report on water supply, water power, the flow of streams and attendant phenomena, by Cornelius C. Vermeule: Final Report State Geologist of New Jersey, Vol. III.

[b] In the combined Genesee River and Oatka Creek record the maximum run-off of 21.22 inches occurred in 1890, when the rainfall is placed at 47.54 inches. This, however, is less reliable than the rainfall and run-off of 1894, which latter is accordingly given the preference.

December to May, inclusive. There may possibly be, therefore, a lower annual run-off than 4.9 inches, even though the total rainfall should exceed 29.84 inches. The rainfall for December to May, inclusive, was 13.04 inches. The run-off for that period was 4.04 inches.

DIVISION OF STREAMS INTO CLASSES.

The foregoing statements indicate that, as regards run-off, streams of the eastern part of the United States may be divided into classes. In the first class will fall streams where the maximum rainfall is from 50 to 60 inches, with corresponding run-off somewhat more than one-half of the rainfall. The minimum run-off will be about one-half the rainfall, or a little less. These statements, it may be again repeated, are general ones, to which there are exceptions.

Another class of streams, of which the Genesee and Muskingum rivers are typical, are those with maximum rainfall on their catchments of 40 to 50 inches and with corresponding run-off somewhat less than one-half the rainfall. The minimum run-off for these streams is from one-fourth to one-sixth of the corresponding rainfall, or from about 16 per cent to 25 per cent.

A further class, the far Western streams, may be mentioned, in which the run-off is only a very small percentage of the rainfall, in some cases not more than 4 per cent to 5 per cent, or at times even less. Probably comprehensive study would further subdivide these streams, but the intention at present is to merely call attention to some of the more marked peculiarities as a basis for final detailed study.

If one takes the streams of the far West, as, for instance, Loup River, in Nebraska, with a catchment area of 13,542 square miles, where the rainfall in 1894, observed at 24 stations, was, on an average, only 12.84 inches and the run-off of the stream did not much exceed 1 inch, he will find entirely different conditions from those above stated. In many cases streams in that locality run much less than 1 inch. For instance, the South Platte, at Denver, Colo., in 1896, with a rainfall of 11.84 inches, ran 0.62 inch. The catchment area at this place is 3,840 square miles. At Orchard, Colo., the South Platte, in 1898, with a rainfall of about 17 inches, ran 0.9 inch. The catchment area at this place is 12,260 square miles. The Republican River, at Junction, Nebr., with a rainfall of about 26 to 28 inches, in 1898, ran 0.39 inch. The catchment here is 25,837 square miles in extent.

The foregoing statements indicate the essential truth of the proposition already announced that, broadly, each stream is a law unto itself. Any formula, for either maximum, average, or mean run-off, which does not take this into account is incomplete.

ESTIMATION OF RUN-OFF FROM RAINFALL DIAGRAMS.

Can run-off of streams be estimated from diagrams of monthly rainfall? The writer has spent considerable time on this problem without

arriving at any very satisfactory conclusion. For some months such a diagram may be made to fit quite closely, while for others differences of as much as 2 or 3 inches appear. The conclusion of the writer is, therefore, that such diagrams are at the best crude approximations. Such study is, however, very fascinating, and it is not surprising that different hydrologists have attempted at various times its solution. Two lines of work may be mentioned. One is, by a combination of a large number of streams and their rainfall, to attempt to produce a universal formula. This, however, as has been already shown, leads to what is, in effect, a hodgepodge. Averages so applied "bring out class likenesses, to the exclusion of individual features."

The other method is to plat rainfall and run-off appearing monthly in inches, as abscissas and ordinates, respectively, and in this way to preserve the individual peculiarities of each stream. In some respects the most satisfactory way is to plat the rainfall and run-off of the storage, growing, and replenishing periods, thus grouping similar characteristics.

STORAGE IN LAKES.

The run-off of a stream is very materially influenced by the number of lakes within its catchment area. If there are many, flood flows may be expected to be very much smaller than they otherwise would be. The temporary pondage in the lakes is the cause of this. The Oswego River is a stream of this character. This stream has a total catchment area of 5,002 square miles, with something like 530 square miles of area of water surfaces—lakes, flats, and marshes. It appears, therefore, that the total area of water surfaces, flats, and marshes is about 10.6 per cent of the whole. The following lakes, ponds, and marshes are included in this catchment area: Canandaigua, Keuka, Seneca, Cayuga, Owasco, Skaneateles, Otisco, Cross, Onandaga, Cazenovia, Oneida, and Montezuma Marsh, together with a considerable number of miscellaneous small ponds and broad flat valleys.

To illustrate how these great natural reservoirs tend to prevent floods it may be mentioned that the configuration of Cayuga outlet, with relation to Clyde River, is such that frequently when there are heavy rainfalls in the catchment area of Clyde River the entire flood flow of Clyde River is discharged into Cayuga Lake, without affecting Seneca River below the mouth of Clyde River at all. It is undoubtedly due to this fact that fall floods on Oswego River are almost entirely unknown.

The evaporation of Oswego River catchment area is exceedingly large—about 28 inches—whence it results that the run-off from a mean annual rainfall of from 36 to 37 inches does not exceed about 9 or 10 inches. Owing to the large lake pondage the flood flows of this stream do not often exceed about 6 cubic feet per square mile per second.[a]

[a] See report to the United States Board of Engineers on Deep Waterways for extended discussion on Oswego River.

COMPUTATION OF ANNUAL RUN-OFF.

No general rule can be formulated for computing annual run-off. The formulas of Mr. Vermeule are excellent formulas of the purely empirical class, applying fairly well to many streams in the northeastern part of the United States, but they do not apply at all to streams of the Middle West and Far West. Nor do they apply to some streams in the northeastern section. Nevertheless, they take into account the ground water, and are the most useful formulas thus far devised. It may be mentioned that Mr. Vermeule especially disclaims any intention of working out any formulas applying outside of the State of New Jersey. His general formula is in the nature of a suggestion.

DISCREPANCIES IN COMPUTATION OF RUN-OFF.

In computing the run-off of various streams small discrepancies will continually appear, and when such do not exceed 1 to 2 inches they are outside the limit of discussion. The question does not admit of such minuteness as to permit the discussion of small differences, although a difference of 2 inches on several thousand square miles would be much more serious than on the usual municipal catchment area of from 20 to 100 square miles. The size of the catchment area should, therefore, in this particular be taken into account.

Moreover, the run-off of streams has thus far been almost universally overestimated. Only a few are really down to the actual fact. Probably in no department of professional work are there more things to be taken into account than here.

ACTUAL GAGINGS PREFERABLE TO GENERAL STUDIES.

While on the general subject of the computation of run-off the writer may repeat what he has said in his report to the United States Board of Engineers on Deep Waterways, viz:

> The data for estimating the water supply of a large canal, especially when on a large scale, should be based, when such data are available, upon actual gagings of streams, rather than on general considerations derived from study of the rainfall alone. An examination of a large number of estimates of canal water supplies, based on the usual method, shows that rainfall data alone are in close cases inadequate for solving a water-supply problem of the magnitude of the one now under consideration. When, however, actual gagings of the streams, extending over a sufficient number of years, are available, there is no reason why a water-supply problem on a large scale may not be worked out with the precision of a proposition in mathematics.

What is here said in regard to water supples for canals is equally true as regards all other water supplies, either municipal or for water power, etc. Further on in the same chapter it is stated:

> It is not intended to say, however, that rainfall data are not of use in a hydrologic discussion. When, as in the present case, in addition to stream gagings an

extended series of such data are available, the argument is made doubly good and the demonstration strengthened.

When records of gagings are available the computation becomes very simple. It is merely a matter of simple addition and substraction.

The complete data required in order to compute the safe possible yield of a stream are as follows:

1. The catchment area.
2. The rainfall of the minimum year, as well as for a series of years.
3. A ground-water diagram of the stream or, lacking such, a diagram for a neighboring stream lying in the same or a similar geologic formation, and, so far as possible, with similar conditions of forestation.
4. The available storage capacity of the stream.
5. The loss by water surface evaporation from the reservoirs, together with an estimate of the loss by percolation.

The data required for ordinary computations may be frequently limited to the totals of the storage, growing, and replenishing periods, although when ground water is to be taken into account the monthly data should be given. The accompanying tables, Nos. 1 to 12, inclusive (pages 85–98), illustrate how such information may be placed in form for convenient use.

FORMULAS FOR RUN-OFF.

At the risk of being considered somewhat elementary the writer will give the more important of the formulas for run-off, expressed in terms of inches on the catchment area.

$$I_m = \frac{n \times Q \times 86400 \times 12}{A \times 640 \times 43560} \tag{5}$$

Whence we deduce,

$$I_m = \frac{n \times Q \times C_1}{A} \tag{6}$$

Also,

$$I_y = \frac{Q \times C_2}{A} \tag{7}$$

and

$$D = \frac{Q}{A} \tag{8}$$

To change gallons per day into inches per month we have:

$$I_m = n \times G \times C_3 \tag{9}$$

Also,

$$G = \frac{I_m}{n \times C_3}. \tag{10}$$

In the reports of the United States Geological Survey, the discharge of streams is sometimes given in acre-feet per month. To reduce such to inches per month, we have, when total acre-feet are given,

$$I_m = \frac{B \times C_4}{A}. \qquad (11)$$

In these formulas,

A=area of catchment in square miles.

B=total acre-feet per month.

D=cubic feet per second per square mile.

G=gallons per day.

I_m=inches in depth per month on the catchment area.

I_y=inches in depth per year on the catchment area.

n=number of days per month.

Q=cubic feet per second flowing from the catchment area, as determined by gagings.

C_1=constant=$\left(\frac{86400 \times 12}{640 \times 43560}\right)$.

C_2=constant=$\left(\frac{86400 \times 12 \times 365}{640 \times 43560}\right)$.

C_3=constant=$\left(\frac{12}{7.48 \times 640 \times 43560}\right)$.

C_4=constant=$\left(\frac{12}{640}\right)$.

The constants, C_1, C_2, C_3, and C_4, are left in form for logarithmic computation. For a given case, catchment area is constant, and A, in the final logarithmic form, will be combined with these.

MAXIMUM DISCHARGE FORMULA.

A considerable number of such formulas have been worked out, but the authors have taken into account so few of the controlling conditions, that they are, at the best, mostly only crude guides, and the writer long ago gave up their use, except in cases where only the roughest approximation was required. Two exceptions may, however, from the peculiar form of the coefficient, be briefly noted, viz:

$$\text{Dickens's formula, } D = C\sqrt{M^3}; \text{ and} \qquad (12)$$

$$\text{Ryves's formula, } D = C\sqrt{M^2}. \qquad (13)$$

In these formulas, D=discharge in cubic feet per second; C=a coefficient, depending for its value upon rainfall, soil, topographical slope, elevation, size of the stream, shape of the catchment, etc., and M=area of the catchment in square miles.

COEFFICIENT TABLE FOR REPRESENTATIVE AREAS.

In Mullins's Irrigation Manual[a] there are given tables for the value of the coefficients of these two formulas, together with the correspond-

[a] Irrigation Manual, by Lieut. Gen. J. Mullins (published for Madras Government), 1880.

ing depth in inches, drained off from the given areas, and the discharges in cubic feet per second. These two formulas are cited because they take into account the principle of the sliding coefficient, as does the Kutter formula, a principle which, all things considered, is the most useful thus far devised. It is true that maximum discharge formulas have been devised taking into account average slope, depth, and intensity of rainfall, area of the mountainous part of the watershed and area of flat part of the same in square miles, and length of stream from source to point of discharge. These formulas, however, also involve from one to two coefficients and become complicated in use without, it is believed, any special gain over the simpler expressions cited. The formulas of Dickens and Ryves, which comprise within the coefficient C everything included in the more complicated formulas, were the forerunners of all formulas of this class.

COOLEY'S FORMULAS.

In an able paper[a] Mr. George W. Cooley, C. E., gives the following formulas for run-off:

For a watershed without lakes,

$$F=0.844\ LRC. \tag{14}$$

For a watershed with large lakes as receiving reservoirs,

$$F=(R+\frac{LRC}{W}-E)\times 0.844\ W. \tag{15}$$

In which, F=flow in cubic feet per second.
R=precipitation in feet.
L=land surface of watershed in square miles.
W=Water surface of reservoirs in square miles.
E=Evaporation in feet.
C=Coefficient of available rainfall.

The constant 0.844 is equal to the number of feet in a square mile divided by the seconds in a year.

In these formulas the sliding coefficient is also recognized. The results, however, are based on averages, although it seems clear enough that in either power or water supply works what is wanted is the minimum run-off for a year or a series of years. For instance, the minimum rainfall at Lake Minnetonka in 1889 was only 18.36 inches, while the maximum in 1892 was 37.90 inches, or a little more than double the minimum. It is evident enough to any person who has gaged streams extensively that the run-off in 1889 must have been very much less than in 1892. In the absence of statements as to the amount of run-off in 1889, the writer can only estimate it, but

[a] Hydrology of the Lake Minnetonka watershed, by George W. Cooley, C. E.: Monthly Weather Review, January, 1899.

he doubts if it were over 10 per cent to 12 per cent of the rainfall. Probably about 2 inches is not far from the mark. What is wanted, therefore, is a concise statement, not only in this case but in every other, of the run-off of the year or series of years of minimum rainfall.

DANGER OF USING AVERAGES.

The writer has dwelt upon the foregoing point somewhat because only a very few of the more advanced students of hydrology have thus far fully appreciated its importance. A very large proportion of all the papers and reports prepared in the last ten years have proceeded on the supposition that safe deductions could be made from an average run-off. It is needless to say that all such are, without exception, erroneous. What is wanted is a clear statement of the minimum, together with the longest period which such minimum may be expected to occupy. A study of the meteorological records of the State of New York shows that the minimum period may be expected frequently to extend over three years. In the writer's report to the United States Board of Engineers on Deep Waterways, in the chapter on the meteorology of New York and the relation of precipitation to run-off, a large number of specific cases are cited, but space will not be taken here to discuss them. This proposition is true for other regions than the State of New York.

DANGER OF USING PERCENTAGES.

A much greater danger arises from the use of percentage of rainfall appearing in run-off. In many reports and papers it is assumed that averages of a series of percentages can be safely taken. The following illustration, with five cases drawn from observation, may be taken to show that this is erroneous:

Run-off, per cent of rainfall.

Case.	Rainfall.	Run-off.	Per cent.
	Inches.	*Inches.*	
1	44.3	20.1	45.37
2	62.5	35	56
3	16.2	1.2	7.41
4	24.3	2.5	10.29
5	40.4	13.1	32.42
	187.7	71.9	5)151.49
			30.29
		Run-off 71.9 / Rainfall 187.7	=38.31
			Difference = 8.02

As a corollary to the preceding proposition, it follows that the ratio between annual rainfall and run-off known as the "run-off coefficient or factor" is essentially misleading. A realization of this fact has led the writer, in his report to the United States Board of Engineers on Deep Waterways, to practically expurgate this statement, or anything approximating to it, from his report. The expressions "average run-off" and "percentage of the rainfall" do not appear.

Attention may also be again directed to the fact that the total run-off of a stream in any given year depends very largely on the run-off of what may be termed the "storage period." Usually about 0.75 to 0.85 of the total rainfall of this period appears as run-off in the stream, while for the summer, or growing period, not more than about 0.1 of the rainfall appears. This great difference is due to greater evaporation, as well as to the absorption of water by plants during this period. The total amount for the year which will appear as run-off in the stream will depend, therefore, very largely on whether or not the rainfall of the storage period—December to May, inclusive—is large or small. If the winter rainfall is relatively large, the run-off will also be relatively large, even though the total rainfall for the year is small. This fact must be taken into account in estimating the value of streams. Whether any given stream is low during the summer months or has then a well-sustained flow will depend very largely on the rainfall of the month of May. When the May rainfall is heavy enough to produce full ground water, the flow is likely to be well sustained, even though the rainfall is comparatively low during the summer months following. If, on the contrary, the May rainfall is so low as to leave a deficiency in ground water for that month, the flow will be low during the summer, even though the rainfall is large.

The foregoing also explains why for certain years the run-off of a stream may be relatively small, even with rainfall considerably above the average.

To more particularly illustrate this, assume a stream with, say, 6 inches of ground-water flow and further assume that on any convenient date the ground water is practically depleted. Under these circumstances, the 6 inches of ground water must fill up before any very large flow can occur. On the other hand, we may consider the sequence of the rainfall such as to leave full ground water, whence it results that there will be a much larger run-off, even though rainfall and other conditions are the same.

What is wanted in a stream, therefore, is as large a ground flow as possible, with small evaporation. That there are very great differences in streams in this respect may be easily seen by examining a series of tables of stream flow. It may be remarked that these two conditions are obtained only on a forested area, for proof of which see Bulletin No. 7, Department of Agriculture, Forest Influences.

EFFECT OF LOW GROUND WATER.

Moreover, when rainfall is below the mean for several months, the ground water may be expected to become continuously lower. This is a subject about which comparatively little is known, although the data are very important in estimating the permanency of a stream. Aside from Mr. Vermeule's, the most satisfactory discussion which the writer has seen is that of Mr. W. S. Auchincloss.[a] This paper, while too long to be abstracted, is nevertheless very interesting, because the author recognizes the limitations of averages. On page 10, after giving a table of the average rise of his sublake, he states:

> Since the table was built up from averages, we must not expect it to emphasize special variations, for the grouping of averages resembles the grouping of pictures in composite photography. The combination invariably brings out class likenesses to the exclusion of individual features. Thus the table loses sight of an extraordinary year like 1889—full of plus quantities—also seasons of drought, like 1894 and 1895. It, however, clearly shows that influx has a tendency to prevail between February and July, inclusive, and efflux to hold the mastery during the remaining months of the year.

Though this paper does not fully recognize the wide variation occurring at different localities, this is probably not due to oversight, but merely to the fact that the author was discussing a specific case. The observations recorded were made at Bryn Mawr, Pa. The paper is valuable and well worth the attention of students of hydrology.

VERMEULE'S FORMULAS.

These formulas are somewhat different from those previously considered. Mr. Vermeule claims to have discovered a relation between evaporation and mean annual temperature. For the relation between annual evaporation and annual precipitation on Sudbury, Croton, and Passaic rivers he gives the following:

$$E=15.50+0.16\ R, \tag{16}$$

In which E=the annual evaporation and R=the annual rainfall.

In the original publication of his formula, in the Report of the Geological Survey of New Jersey,[b] Mr. Vermeule allowed for other catchment areas an increase or decrease of 5 per cent from values given for evaporation on the Sudbury, Croton, and Passaic rivers. The following is his general formula for all streams:

$$E=(15.50+0.16\ R)\ (0.05\ T-1.48) \tag{17}$$

This, however, he states is merely a suggestion. His purpose is to deduce laws which hold for the State of New Jersey alone.

In these formulas the evaporation is taken to include all the various losses of water to which a catchment area is subject, including direct evaporation as well as water absorbed and transpired by plant growth, etc. Hence,

$$F\ (\text{run-off})=R-E. \tag{18}$$

[a] On Waters within the Earth and Laws of Rainflow, by W. S. Auchincloss, C. E. Philadelphia 1897.

[b] Report on water supply, water power, the flow of streams, and attendant phenomena, by C. C. Vermeule: Final Report State Geologist of New Jersey, Vol. III. Trenton, 1894.

Mr. Vermeule gives the following formulas for the Sudbury, Croton, and Passaic rivers:

$$\text{December–May, } E=4.20+0.12\ R; \tag{19}$$

$$\text{June–November, } E=11.30+0.20\ R. \tag{20}$$

These formulas take into account the fact that evaporation is low in the winter months and high during the summer.

Mr. Vermeule also gives the following formula for computing monthly evaporation from the monthly rainfall for Sudbury, Croton, and Passaic catchment areas:

[e=monthly evaporation; r=monthly rainfall.]

December	$e=0.42+0.10\ r$
January	$e=0.27+0.10\ r$
February	$e=0.30+0.10\ r$
March	$e=0.48+0.10\ r$
April	$e=0.87+0.10\ r$
May	$e=1.87+0.20\ r$
June	$e=2.50+0.25\ r$
July	$e=3.00+0.30\ r$
August	$e=2.62+0.25\ r$
September	$e=1.63+0.20\ r$
October	$e=0.88+0.12\ r$
November	$e=0.66+0.10\ r$
Year	$e=15.50+0.16\ r$

(21)

To obtain the monthly evaporation for other streams the results obtained are multiplied by the following:

$$(0.05\ T-1.48.)$$

In which T=mean annual temperature.

At this point Mr. Vermeule was confronted by the difficulty of ground storage. In regard to the effect of this it may be mentioned that, with rainfall above the average continuously for several years, ground water may be expected to stand above its average height, yielding to streams the maximum flow possible to ground water. On the other hand, when the rainfall is below the average for a number of years ground-water flow will be lower, becoming less and less as the rainfall approaches the minimum. It is very important that this fact be taken into account, because without it one is certain to fall into error. The formulas for average depletion may be given as follows:

$$d_2=d_1+e+f-r; \tag{22}$$

$$d=\frac{f}{2}+d_1-\frac{r-e}{2}. \tag{23}$$

In which d_1 and d_2=depletion at end of previous month and for the month under consideration; d=average depletion; e and r=monthly evaporation and monthly rainfall, respectively, and f=computed monthly flow.

The foregoing does not fully express the use of these formulas, but as all that is wanted at this time is an illustration of methods, this brief account may be deemed sufficient.

Mr. Vermeule gives a diagram showing ground flow for the several different streams mentioned for a given depletion, which is to be used in conjunction with the foregoing formulas. In his opinion the diagrams present advantages over a ground-flow formula with varying constants and coefficients for different streams, being more readily compared and insuring greater accuracy. Later, in his report on forests,[a] Mr. Vermeule modifies his formula, as follows:

$$E=(11+0.29\ R)\ M. \qquad (24)$$

In which E=evaporation, R=rainfall, and M is a factor depending upon the mean temperature of the atmosphere. The writer understands Mr. Vermeule to say that this is also an expression for annual evaporation.

Values of M for given mean annual temperatures are as follows:

40°, 0.77; 41°, 0.79; 42°, 0.82; 43°, 0.85; 44°, 0.88; 45°, 0.91; 46°, 0.94; 47°, 0.97; 48°, 1; 49°, 1.03; 50°, 1.07; 51°, 1.10; 52°, 1.14; 53°, 1.18; 54°, 1.22; 55°, 1.26; 56°, 1.30; 57°, 1.34; 58°, 1.39; 59°, 1.43; 60°, 1.47; 61°, 1.51.

In a table on page 149 of the Report on Forests Mr. Vermeule compares observed annual evaporation with computed annual evaporation. The following are some of the differences which appear:

On the Genesee River the observed annual evaporation is 27.2 inches; computed annual evaporation, 20.6 inches; the observed annual evaporation, therefore, is 6.6 inches, or 32 per cent, greater than the estimated annual evaporation. On the Musconetcong River the observed, as compared with the computed evaporation, is 13 per cent less; on the Pequest it is 17 per cent less; on the Paulinskill it is 14 per cent less; on the Tohickon, 32 per cent less; on the Neshaminy, 16 per cent less; on the Perkiomen, 17 per cent less; on the Desplaines, 21 per cent greater; on the Kansas, 15 per cent greater; on the Upper Hudson, 10 per cent greater; on Hemlock Lake, 18 per cent less; on the Potomac, 17 per cent less; on the Savannah, 13 per cent less. For the rest of the streams cited in the table the agreement is closer than this.

The observed annual evaporation is 32 per cent greater than the computed annual evaporation on the Genesee River and 32 per cent less on Tohickon Creek—a range of 64 per cent. Somewhat similar differences are found on other streams where the gagings are approximately right. As to the gagings referred to in the report on forests, the writer will show farther on in this paper that gagings of Genesee and Hudson rivers are, on the whole, probably the best thus far made in the United States. Tohickon, Neshaminy, and Perkiomen creeks have been gaged by Francis weirs, and are, with the exception of Tohickon, considered approximately right. The difficulty here is probably in the flood flows. The writer understands

[a] Report on forests, by C. C. Vermeule: Ann. Rept. State Geologist New Jersey for year 1899. Trenton, 1900.

that Mr. Vermeule used the Francis formula for a sharp-crested weir. The gagings of Sudbury, Cochituate, and Mystic rivers have been deduced, it is believed, by Mr. Francis's formula for the Merrimac dam. As to Desplaines River, a discharge curve determined by current meter has, it is believed, been applied.[a] The English streams cited, Lea, Wandle, Thames, etc., have probably been gaged by a sharp-crested weir, and the others mostly by the current meter and a rating table.

RUSSELL'S FORMULAS.

Mr. Thomas Russell[b] gives the following formulas for the run-off of the Ohio, Upper Mississippi, and Upper and Middle Missouri valleys, in terms of the annual rainfall. For the Ohio River the formula is as follows:

$$O=0.600+0.95\ R-0.90\ R\ (0.975\ e-0.421\ e^2+0.626\ e^3). \quad (25)$$

For the Upper Mississippi it is:

$$O=0.50+0.93\ R-0.88\ R\ (1.131\ e-0.383\ e^2). \quad (26)$$

For the Upper and Middle Missouri it is:

$$O=0.12+0.98\ R-0.93\ R\ (0.91\ e-0.220\ e^2+0.009\ e^3). \quad (27)$$

In these formulas R is the rainfall for the month in cubic miles; e is the quantity of water required to saturate the air at any time, equal to the difference between what the air contains and the amount if it was saturated; and O is the outflow or run-off.

These formulas are interesting in the present connection, because they recognize the fact that every stream must have its own formula. The variation in run-off on the Ohio, Mississippi, and Missouri rivers will be observed on inspection of the formulas. Like all formulas of this class they are subject to considerable variation. In the month of October, 1881, the computed outflow of Missouri River was 4.9 cubic miles and the observed flow was 1.6 cubic miles, a difference of 3.3 cubic miles.

RELATION BETWEEN CATCHMENT AREA AND MAXIMUM, MINIMUM, AND MEAN RUN-OFF.

It is quite common for hydrologists to assume that there is a relation between catchment area and maximum, minimum, and mean run-off, the general proposition being that mean annual run-off varies inversely as the size of the catchment, and that maximum run-off, or flood flow, varies directly as the size of the catchment.

In order to gain some idea as to the applicability of this proposition, the résumé of discharge data, in the Twentieth Annual Report of the

[a] Data pertaining to rainfall and stream flow, by Thomas T. Johnston: Jour. Western Soc. Engrs., Vol. I, No. 3, June, 1896.

[b] Rainfall and river outflow in the Mississippi Valley, by Thomas Russell: Ann. Rept. Chief Signal Officer for the year 1889, Part I, Appendix 14.

United States Geological Survey, pages 46–64, has been examined. This table includes about 225 streams in various portions of the United States, with records ranging from 18 to 20 years in length to 1 year. A few of the best-known streams—as, for instance, the Croton and Sudbury—are not given in detail, although the large number included in this table, it is believed, is sufficient to settle definitely this question. Only a very few of the results will be referred to here.

In the first place, it appears certain that with equal rainfall there is no very definite relation between size of catchment area and mean annual run-off. For instance, the Kennebec, at Waterville, Me., with a catchment area of 4,410 square miles, has a mean annual run-off for 6 years of 22.4 inches. The Cobbosseecontee, at Gardiner, Me., with a catchment area of 230 square miles, has a mean annual run-off for 6 years of 18.5 inches. The Androscoggin, at Rumford Falls, Me., with a catchment area of 2,220 square miles, has for 6 years a mean annual run-off of 24.2 inches. The Presumpscot, at Sebago Lake, Me, with a catchment of 470 square miles, has a mean annual run-off for 11 years of 21 inches. The Merrimac, at Lawrence, Mass., with a catchment area of 4,553 square miles, has a mean annual run-off for 9 years of 21.3 inches. Aside from the Androscoggin River these five streams support the proposition that the run-off varies in some degree directly as the drainage area instead of inversely.

As to the maximum run-off, or flood flow, there is apparently some slight relation, although even this is less definite than has usually been assumed.

As to minimum run-off, there is apparently no relation, extremely small flows happening on large streams as well as on the smallest. There is, however, much more definitely a relation between the run-off and the rainfall, run-off increasing as rainfall increases, and conversely.

As regards the division of streams into classes in proportion to size of catchment area, it appears, therefore, that aside from maximum run-off one is not, on present information, justified in such classification, and even in cases of flood flow it is quite probable that there are other considerations of such importance as to render a classification of this character inexpedient.

In the rivers for which data are given in this paper the catchment areas vary from 18.9 square miles for Lake Cochituate to 10,234 square miles for the Connecticut River. Since there is no very definite relation between size of catchment and run-off there is no reason why the comparison may not be made of streams having such large difference in size of catchment. For some streams—as, for instance, Pequannock River—where the slopes are very steep, the run-off is somewhat higher than it would be with other conditions the same, but with flatter slopes. But generally the degree of forestation and other elements exercise so much more important an influence that a comparison, without regard to size of catchment area, may be legitimately

made. Nevertheless, this proposition is possibly debatable, and for the present the conclusions drawn are tentative merely.

THE EXTREME LOW-WATER PERIOD.

In the discussion of Tables Nos. 1–12, inclusive, the writer has given the low water of the minimum year, but this does not usually include the extreme low-water period, which is in almost every case much more than one year. Space will not be taken to show the extreme low-water periods of all these tables. It is considered that illustrations from Muskingum and Genesee rivers are sufficient. This information is given in Tables Nos. 14 and 15.

On the Muskingum River three low-water periods have occurred during the time covered by the gagings. The first was from December, 1887, to November, 1889, inclusive, a period of twenty-four months, during which the total run-off was 18.55 inches, or if we assume a reservoir on said stream of 20 square miles water surface, the total net run-off becomes 18.15 inches. The computations of evaporation, etc., for such a reservoir, neglecting variation in water surface, are as follows. Assume an annual evaporation of 40 inches and with distribution for the several months as per column 1 in the following table. Since the water surface area is 20 square miles, it becomes 20/5828 of the whole, or 1/292. Hence, water surface evaporation is 1/292 of 40 inches, and making the computation for each month, we have the quantities as per column 2:

Total evaporation and evaporation per square mile of water surface in Muskingum Basin.

Month.	1. Total evaporation.	2. Evaporation per square mile of water surface.
January	1.00	0.0034
February	1.10	.0037
March	1.70	.0058
April	3.00	.01029
May	4.60	.01578
June	5.65	.01938
July	6.10	.02092
August	5.60	.01921
September	4.15	.01423
October	3.35	.01149
November	2.25	.00772
December	1.50	.00514
	40.00	

With some allowance for percolation, leakage, etc., the total is taken at 0.40 of an inch per year. Analyzing the first period, we find that for 24 months there was an average flow of 0.76 inch per month, for 12 months an average flow of 0.67 inch, and for 9 months an average flow of 0.43 inch.

The second low-water period was from May, 1891, to January, 1893, inclusive, a period of 21 months, during which time the net run-off was 17.2 inches, yielding for the whole 21 months an average of 0.82 inch and for 7 months an average of 0.36 inch.

The most extreme low-water period was from April, 1894, to November, 1895, inclusive, a period of 20 months, during which time the net run-off did not exceed under the assumed conditions 7.09 inches. The average run-off for 20 months was 0.354 inch and for 7 months 0.116 inch.

On Genesee River there have been two low-water periods during the time covered by the gagings. The first was from June, 1894, to February, 1896, a period of 21 months, during which time there was a gross run-off of 13.02 inches. Evaporation has been computed for a proposed reservoir of 12.4 square miles water-surface area, with allowance for actual height of water during the different months. On this basis and with a small allowance for percolation, leakage, etc., the total evaporation loss for the 21 months becomes 0.65 inch, leaving a net run-off of 12.37 inches. The average run-off for 21 months was 0.59 inch, or, if we assume 1.43 inches left in reservoir at end of period, the average allowable run-off becomes 0.52 inch. For 10 months, with some allowance, the average run-off is 0.30 inch and for 7 months 0.10 inch.

The second period was from June, 1896, to December, 1897, a period of 19 months, during which time the net run-off was 13.24 inches. The average run-off for 19 months, with 1.24 inches left in reservoir at end of the period, was 0.63 inch; for 8 months, 0.31 inch, and for 6 months, 0.17 inch. These figures, without being exhaustive, show that Genesee River is a somewhat better water yielder than Muskingum River.

A large number of other interesting and valuable tabulations could be drawn from these data, especially those relating to storage. But since this element is not specially considered in this paper they are not given. In any case, enough has been said to sustain the statement that streams vary, not only as regards their total capability of yielding water, but as regards its distribution. In order to develop a stream to its maximum capacity for either water power or municipal purposes it is absolutely indispensable to have a series of carefully prepared gagings. Lacking these, there should be gathered as long a rainfall record as possible, from which, by comparison, the approximate run-off of the stream may be computed. A carefully taken series of gagings is, however, in every way preferable.

VARIATION IN WEIR MEASUREMENTS.

The writer has shown[a] the considerable variation in weir measurements due to difference in form of weir alone. So great are these that any conclusions based upon the data of sharp-crested weirs applied to other forms are extremely unsatisfactory. In one case of a flat-crested weir, the flow at a given depth is only 75 per cent of what it is over a sharp-crested weir. Variations of from 5 per cent to 20 per cent are common, as may be easily observed by examining the tables in the paper cited.

In view of the importance which gagings are now shown to bear in estimating the value of a stream for water power or city water supply, in future every statement of stream flow should be accompanied by a concise statement of the method of gaging used, thus permitting hydrologists to judge of the general reliability of the method. Had this been done in the past, some of the uncertainty which now attaches to many gaging records would undoubtedly be removed.

GENESEE AND HUDSON GAGINGS REDUCED TO SHARP-CRESTED WEIR MEASUREMENTS.

The writer has shown in another place that Genesee River gagings which were made by him have been reduced to sharp-crested weir measurements. As to the Hudson gagings, Pl. CXXVII in the Report to the United States Board of Engineers on Deep Waterways may be cited. This plate is a comparison of the discharge over weirs by different formulas, and it appears from it that Mullins's formula for a flat-crested weir, which has been used for the Upper Hudson gagings, at a depth of 4 feet gives results less than Francis's formula for a sharp-crested weir by about 10 per cent. However, in order to simplify the computation and to avoid velocity of approach, the width of the crest was taken at 5 feet. Again, the crest at Mechanicville is not flat, but is slightly sloping backward. The sloping front probably affects the flow to increase it somewhat. There are also flashboards used during low water, which are properly computed by Francis's formula for a sharp-crested weir. These several elements undoubtedly make the problem somewhat complicated, but taking everything into account it is probable that the results as computed are not far from right. They may, however, be in error as much as 2 inches per year.[b]

As regards the relation between mean annual temperature and evaporation, the questions raised by Mr. Vermeule are very interesting and have received considerable study from the writer ever since the publication of Mr. Vermeule's report in 1894. This study has been specially directed toward determining whether there was any

[a] On the flow of water over dams: Trans. Am. Soc. C. E., Vol. XLIV, p. 220.
[b] See the diagrams of Hudson and Genesee rivers on this point.

way of showing by diagrams, definitely, that any such relation really existed. A concise résumé of such study will now be given.

EVAPORATION.

FITZGERALD'S FORMULA FOR EVAPORATION.

In the first place we may consider Mr. FitzGerald's formula for evaporation,[a] which is:

$$E=\frac{(V-v)\left(1+\frac{W}{2}\right)}{60}. \qquad (28)$$

In this formula V=the maximum force of vapor in inches of mercury corresponding to the temperature of the water; v=the force of vapor present in the air; W=the velocity of the wind in miles per hour; and E=the evaporation in inches of depth per hour. It can be shown that there is going on nearly always a condensation of moisture from the air upon any water surface. At the same time there is going on a loss of moisture from the water surface by evaporation. The intensity of both these operations depends upon the difference in temperature between the air and any water surface with which it may be in contact. When the temperature of air and water is the same, both processes stop. Evaporation is, therefore, in effect the measure of the difference of these two exchanges. The velocity of the wind is also seen to exert a very decided effect on the intensity of evaporation.

In the foregoing formula, v, the force of vapor present in the air is computed by the following:

$$v=V-\frac{0.480\,(t-t')}{689-t'}h, \qquad (29)$$

In which v=the force of vapor in the air at the time of the observation;

t=the temperature of the air in centigrade degrees, indicated by the dry thermometer;

t'=the temperature of evaporation given by the wet thermometer;

V=the force of vapor in a saturated air at the temperature t'; and

h=the height of the barometer.

There is no difference between evaporation from a water surface and evaporation from land, except that on a water surface it goes on continuously, while on land evaporation may be interrupted from lack of something to evaporate. The preceding formula shows that the force of vapor is dependent upon the difference of the dry and wet bulb thermometers, and not in any degree upon the mean annual temperature.

[a] Trans. Am. Soc. C. E., Vol. XV, pp. 581-646.

EVAPORATION RELATIONS.

Prof. Cleveland Abbe[a] gives the following relations of evaporation, as established by Prof. Thomas Tate:

(*a*) Other things being the same, the rate of evaporation is nearly proportional to the difference of the temperatures indicated by the wet-bulb and dry-bulb thermometers.

(*b*) Other things being the same, the augmentation of evaporation due to air in motion is nearly proportional to the velocity of the wind.

(*c*) Other things being the same, the evaporation is nearly inversely proportional to the pressure of the atmosphere.

(*d*) The rate of evaporation of moisture from damp, porous substances of the same material is proportional to the extent of the surface presented to the air, without regard to the relative thickness of the substances.

(*e*) The rate of evaporation from different substances mainly depends upon the roughness of, or inequalities on, their surfaces, the evaporation going on most rapidly from the roughest or most uneven surfaces; in fact, the best radiators are the best vaporizers of moisture.

(*f*) The evaporation from equal surfaces composed of the same material is the same, or very nearly the same, in a quiescent atmosphere, whatever may be the inclination of the surfaces; thus a horizontal plate with its damp face upward evaporates as much as one with its damp face downward.

(*g*) The rate of evaporation from a damp surface (namely, a horizontal surface facing upward) is very much affected by the elevation at which the surface is placed above the ground.

(*h*) The rate of evaporation is affected by the radiation of surrounding bodies.

(*i*) The diffusion of vapor from a damp surface through a variable column of air varies (approximately) in the inverse ratio of the depth of the column, the temperature being constant.

(*j*) The amount of vapor diffused varies directly as the tension of the vapor at a given temperature, and inversely as the depth of the column of air through which the vapor has to pass.

(*k*) The time in which a given volume of dry air becomes saturated with vapor, or saturated within a given percentage, is nearly independent of the temperature if the source of vapor is constant.

(*l*) The times in which different volumes of dry air become saturated with watery vapor, or saturated within a given per cent, are nearly proportional to the volumes.

(*m*) The vapor already formed diffuses itself in the atmosphere much more rapidly than it is formed from the surface of the water. (This assumes, of course, that there are no convection currents of air to affect the evaporation or the diffusion.)

EFFECT OF WIND AND OTHER METEOROLOGICAL ELEMENTS.

That the velocity of the wind must have a very material effect upon evaporation, and hence upon the run-off of streams, is at once apparent on inspection of Mr. FitzGerald's evaporation formula, given in a preceding chapter. Again, on examining the annual summaries in the report of the Chief of the Weather Bureau the average yearly velocity of wind is found to vary from about 3 miles to 16 or 18 miles.

[a] Preparatory studies for deductive methods in storm and weather predictions, by Prof. Cleveland Abbe: Ann. Rept. Chief Signal Officer for 1889, Part I, Appendix 15.

With other conditions the same, evaporation will be much larger with a higher wind velocity.

The preceding summary of evaporation relations further shows that evaporation will vary in some degrees in proportion to pressure, temperature, moisture—which may be taken to include dew-point, relative humidity, vapor pressure, precipitation, and cloudiness—and, finally, in proportion to average velocity of the wind. It may also be expected to vary in some degree in proportion to electrical phenomena—thunderstorms, auroras, etc.—but as yet we know so little about these that they can be no more than mentioned. The writer, however, believes that studies in the direction here indicated would be very prolific of results. For this purpose two or three stations, observing all the elements herein enumerated, should be established in each catchment area.

In the present study an attempt has been made to correlate these elements with the run-off, but, aside from the rainfall, the data are too indefinite for satisfactory results. It is for these reasons, with others, that the writer is able to give only tentative conclusions in regard to the relation of rainfall to the run-off of streams.

PERSISTENCY OF RATE OF EVAPORATION.

The persistency of the amount of evaporation for any given stream at about the same figure through long periods of time was first pointed out by Messrs. Lawes, Gilbert, and Warrington in their classical paper, On the Amount and Composition of Rain and Drainage Waters Collected at Rothampsted, published in the Journal of the Royal Agricultural Society of England for 1881. As to why evaporation exhibits such persistency these distinguished authors consider it largely due to the fact that the two principal conditions which determine large evaporation—namely, excessive heat and abundant rain—very rarely occur together. The result is, especially in the English climate, a balance of conditions unfavorable to large evaporation. In a wet season, when the soil is kept well supplied with water, there is at the same time an atmosphere more or less saturated, with an absence of sunshine; while in dry seasons the scarcity of rain results in great dryness of the soil, with scant, slow evaporation.[a]

NEGATIVE EVAPORATION.

In a strictly scientific sense this term is taken to mean that when the temperature of the evaporating surface is lower than the dew-point, water is deposited on that surface. As regards the rainfall, run-off, and evaporation tables, herewith included, negative evaporation means that the run-off for certain months is greater than the rainfall. Sometimes this may legitimately happen when a heavy rain-

[a] Since the persistency of evaporation has been extensively discussed in the writer's paper on Stream flow in relation to forests (see footnote on p. 54), it is merely touched on here.

fall comes at the end of the month, or when, with much snowfall, the temperature of the month is mostly below freezing. In order to show as much as possible in regard thereto, the writer gives the detail for each of the 12 tables, together with a tentative view as to the real significance of the so-called negative evaporation.

On Muskingum River, during the 8 years gaged, negative evaporation is shown only twice for one month.

On Genesee River the detailed tabulation shows negative evaporation 5 times for one month and once for two consecutive months, a total of 7 months in all.

On Croton River, for the entire period of 32 years, negative evaporation is shown 29 times for one month and 6 times for two consecutive months, a total of 41 months in all.

On Lake Cochituate negative evaporation is shown 24 times for one month, 3 times for two consecutive months, and twice for three consecutive months, a total of 36 months in all. Negative evaporation is also shown once for the entire storage period in 1891.

On Sudbury River it is shown 16 times for one month, 9 times for two consecutive months, and 3 times for three consecutive months, a total of 43 months in all.

On Mystic Lake it is shown 12 times for one month, twice for two consecutive months, once for three consecutive months, and once for four consecutive months, a total of 23 months in all.

On Neshaminy Creek negative evaporation is shown 6 times for one month, 5 times for two consecutive months, and once for three consecutive months, a total of 19 months in all.

On Perkiomen Creek negative evaporation is shown 10 times for one month, twice for two consecutive months, and twice for three consecutive months, a total of 20 months.

On Tohickon Creek it is shown 11 times for one month, 4 times for two consecutive months, twice for three consecutive months, and once for four consecutive months, a total of 29 months. The year 1884 shows a negative evaporation of 1.21 inches for the entire storage period, and the year 1899 a negative evaporation of 2.37 inches for the entire storage period. This latter is so large that it has seemed best to reject the year 1899. Probably the year 1884 should also have been rejected, but it has been allowed to remain.

On Hudson River negative evaporation is shown 7 times for one month and 4 times for two consecutive months, a total of 15 months.

On Pequannock River it is shown 9 times for one month and 5 times for two consecutive months, a total of 19 months.

On Connecticut River negative evaporation is shown 6 times for one month, 9 times for two consecutive months, and once for three consecutive months, a total of 27 months. The year 1873 shows -3.64 inches in the storage period, and for the year 1874 the positive evaporation of the storage period is only 0.04 inch; for 1876 it is for

the same period —2.24 inches. The years 1873, 1874, and 1876 have been rejected in computing the means.

The writer has no doubt that, except in cold climates, when negative evaporation occurs for three or more consecutive months, there is an error in the gagings. He also doubts their accuracy somewhat when negative evaporation appears for two consecutive months. As regards the storage period, there is no difficulty in accepting it for one month as true, because rainfall or snowfall at the end of the month can be easily carried over to the next. This is also true sometimes for two months, but for the present it seems quite doubtful that other than in exceedingly rare cases would negative evaporation occur for three consecutive months. Its occurrence for six consecutive months, or for the entire storage period, is believed to be impossible. It may, however, be again pointed out that its occurrence renders an attempt at monthly diagrams showing the relation between rainfall and run-off absurd.

Assuming that the foregoing propositions are reasonably true, it follows that the frequency of the occurrence of negative evaporation in gaging records may be in some degree a criterion as to their accuracy. The writer, however, does not wish to urge this very strongly, but merely to point it out as a possibility.

In reference to Tables Nos. 1–12, inclusive, it may be stated that these are really all that are available for such a discussion. There are several stream-flow records which are nearly as accurate as any herein included, but unfortunately they were not accompanied by records of rainfall, and the considerable labor of compiling and reducing these has prevented their use. There are also some records, with rainfall included, of which the gagings are not considered very reliable, and which, for the present, are left untouched on that account.

In a report on the flow of the river Thames, by A. R. Binnie, chief engineer of the London county council,[a] the matter of negative evaporation is elaborately discussed, and in order to obtain all the information possible about it Mr. Binnie applied to George J. Symons, F. R. S., to assist him in arriving at some approximate idea on the subject. Mr. Symons submitted an exceedingly lucid and conclusive report. Eleven distinct cases of negative evaporation were submitted to him for study and comment. In regard to these he arrived at the following conclusions:

(1) Under normal conditions a fall of rain will increase the flow at Teddington weir on the second day after it falls.

(2) Under normal conditions the water running off from any given fall of rain will all reach Teddington weir before the tenth subsequent day.

(3) In the winter an interval of two months, or in extreme cases even more, may elapse between the precipitation of moisture from the clouds and its flow over Teddington weir.

[a] Report on the Flow of the River Thames, by A. R. Binnie. Publication of the London County Council, dated November 1, 1882.

As a consequence of (2) it is clear that a heavy rainfall on the last days of any month may not appear at the point of gaging until the next month. Mr. Symons also states that the one great fact which has been impressed upon him by these investigations is the great effect of winter frosts in regulating the flow of the river Thames and in mitigating winter floods.

These conclusions are more especially intended to apply to the river Thames. Hence, while it is true that so-called negative evaporation exists on all of the streams considered, the conditions are nevertheless very different, and in the United States the effect of holding back the flow of streams by frosts is in very many cases to precipitate a flood of water later on. This element would hardly be considered with us as either a river regulator or as mitigating floods.

GROUND WATER.

MOVEMENTS OF GROUND WATER.

In an extensive paper Prof. F. H. King has very clearly defined many of the underlying principles covering the movements of ground water.[a] In the beginning of his paper Professor King remarks that there is no single substance entering into the structure of the earth which has played and is playing so important a part as water. It penetrates the soils, sands, and rocks of the land areas in such large quantities that sand and sandstones lying below water level may contain as high as 38 per cent of their volume of water. Even the quantity stored in soil, gravel, and clay is very large. The water in a saturated soil or clay may range from 22 per cent up to 40 and even 50 per cent of its dry weight. The following table, giving the water capacity of undisturbed soils when lying below the plane of saturation, shows the amount of water which may be contained in various soils under natural conditions:

Water capacity of undisturbed soils.

Kind of soil.	Depth of layer.	Per cent of water.	Inches of water.
	Inches.		
Marly loam	0 to 12	41.3	5.88
Reddish clay	12 to 24	28.1	5.03
Do	24 to 36	28.4	5.07
Clay with sand	36 to 48	24.8	4.67
Very fine sand	48 to 60	17.4	3.76
Total			24.41

[a] Principles and conditions of the movements of ground water, by F. H. King: Nineteenth Ann. Rept. U. S. Geol. Survey, Part II.

Professor King states that there are many reasons for believing that water penetrates the fissures and interstices of the earth to depths even exceeding 10,000 feet. If the waters so inclosed form no larger part than 1 per cent of the weight of the material, with a specific gravity of 2.65, the amount of inclosed water would be sufficient to form an envelope 265 feet deep.

Moreover, Professor King's observations show that ground water is very easily disturbed and is constantly in motion. It responds readily to changes in barometer, temperature, etc. It is evident that these movements are not only closely related to the rainfall, the source of ground water, but that the run-off of streams is considerably influenced thereby.

GROWTH OF STREAMS BY ACCESSION OF GROUND WATER.

It is evident, without special discussion, that streams winding through the thread of a valley must receive accession to their volumes little by little as they move along. A few such, cited by Professor King, may be mentioned.

1. The Los Angeles River, in California, was measured in the winter of 1897–98, showing that in a distance of 59,088 feet (11.19 miles) the river increased in volume from 20.41 cubic feet per second to about 80 cubic feet per second. The width of the river will average perhaps 40 feet, and adding to this 5 feet on each bank, through which water may enter the stream, we have a seepage surface of 50 square feet per linear foot of length, whence we have a total seepage surface of 2,954,400 square feet. We have then for this particular case an average rate of seepage of 0.0000203 of a cubic foot per square foot per second.

This computation is made without reference to gradient, which is unknown.

A profile of the growth of the Los Angeles River is also given, which shows that the rate of accession is not uniform, but that much the larger portion of it takes place in the upper 47 per cent of the total length.

2. The West Los Angeles Water Company has a flume about 4,500 feet long sunk below the normal level of the ground water for the purpose of collecting the same and delivering it at the surface lower down the valley. The flume is described as being rectangular in cross section, 4 feet deep and 5 feet wide, with open bottom, but covered and provided with wooden sides.

On January 21, 1897, the flume was discharging 7.2 cubic feet per second; on November 19, 1896, 7.29 cubic feet per second; on March 1, 1896, 8.5 cubic feet per second; on November 23, 1895, it is said to have discharged 10.1 cubic feet per second, but in April, 1898, it was discharging 6.2 cubic feet per second.

3. The rate of seepage into the infiltration pipes of the Crystal

Springs Land and Water Company may be mentioned. This system consists of an east-and-west line of infiltration pipes sunk below the normal level of the ground water of the river valley, which join in their lower portion, when they deliver the water collected by them to the surface. The pipes are glazed sewer tile, laid double upon boards in the bottom of a ditch, the space immediately around them being filled with coarse gravel and sand, while above the gravel the cut is filled with material from the excavation. The east infiltration line has a total length of double tile consisting of 1,343 feet of 24-inch tile, 300 feet of 20-inch tile, 1,385 feet of 15½-inch tile, and 619 feet of 12-inch tile, making a total of 3,647 feet of double line. The west infiltration line, also double, has a measured length of 1,721 feet, all of 15-inch pipe.

The water discharged from the system on February 1, 1898, was 9 cubic feet per second, or a mean rate of 0.001677 of a cubic foot per second for each linear foot of length.

Professor King's paper includes the discussion of very many questions of great practical importance—as, for instance, the rate of filtration of water through soil, percolation of water into undisturbed field soil, rate of lateral flow through sands, time required to lower the ground-water level of a system of infiltration pipes, rate of flow of water into wells, flow of water into driven-well points, rate of pumping from driven well compared with rate from open well, and many others which, however, are not referred to here from lack of space. The paper is worthy of close attention from everybody interested in ground water.

The paper also includes a concise summary of what has been done by a number of European observers. A few papers on ground water have appeared since the publication of Professor King's, which, however, the writer has not seen.

In connection with the studies of Professor King, Prof. Charles S. Slichter undertook a theoretical investigation of the motion of ground water, and his paper also appears in the Nineteenth Annual Report of the United States Geological Survey.[a]

In this paper Professor Slichter studies the question mostly from the mathematical point of view. As an example of the nature of the problems touched by him the following may be cited:

Given, a uniform bed of unfissured sandstone 100 feet thick, lying between impervious layers and dipping 5 feet per mile; given, further, (*a*) a uniform temperature of 10° C.; (*b*) a pore space of 30 per cent; (*c*) an effective size of grain of 0.15 mm.; (*d*) an effective head of 10 feet, and, (*e*) supposing no cementing or clogging material between grains; required, the possible discharge in cubic feet per minute per foot of vertical section into a vertical fissure extending at right angles to the dip and constantly filled with water, when the fissure is 20, 40, 60, 80, 100, 120, 140, 160, 180, and 200 miles from the border of the collecting area.

[a] Theoretical investigation of the motion of ground waters, by Prof. Chas. S. Slichter: Nineteenth Ann. Rept. U. S. Geol. Survey (1897-98), Part II.

The rainfall on the catchment area is sufficient to maintain a constant overflow across its border.

The paper concludes with a list of about 80 titles of papers on ground water and related topics.

RELATION OF GEOLOGIC STRUCTURE TO RUN-OFF.

It is somewhat uncertain whether difference in soil due to difference in character of rocks has much influence on the run-off, although casually it appears that sandy soils, from their porousness, do considerably affect the result. Recent studies of this subject have shown (1) that in many river basins the annual run-off stands in a nearly constant relation to the rainfall, and (2) that this constancy is more marked when the excess rainfall above a certain minimum annual depth is considered. This latter statement is equivalent to saying that if the yearly rainfall is less than such minimum depth little or no run-off will take place.

The general truth of this proposition is shown by many Western streams where the run-off is little or nothing. In New Jersey 12 inches of rain during the summer season produce a run-off of 1.5 inches, though others have stated a somewhat different relation. In the State of New York from 1.7 to 2 inches may be considered the general range. As to the amount of rain required to produce any run-off at all, from 12.5 to 16.5 inches have been given. For this minimum many Western streams do not run more than 0.25 to 0.5 inch, and some even are perfectly dry. These statements indicate that the character of the soil, nature of vegetation, the elevation, etc., are of comparatively small importance as regards relation between the yearly volumes of rainfall and run-off. If, however, we consider the rainfall and run-off of the several periods, as shown by the accompanying tables, it is not entirely certain that these propositions are other than approximately true. The weight of evidence indeed is, on the whole, negative. Mr. Vermeule is disposed to attribute nearly all of the differences between streams to difference in geology, and accordingly gives a geologic classification for the New Jersey streams. Mr. Vermeule says:

As a rule, the watersheds which lie upon the same geological formation will be found to have a strong resemblance, both in the character of flow and in the chemical composition of the waters.

Yet, as will be shown later, the Genesee and Oswego rivers, two streams with approximately the same run-off, lie mostly in different geologic formations. As regards quality of soils, Mr. Vermeule also says:

It may be inferred that the kind of soil has much less to do with the amount of evaporation than has the temperature.

As regards the relation between geology and run-off, it is undoubtedly complicated, although it is interesting to note that in the State

of New York streams which flow from the north into Mohawk River, after crossing over a narrow strip of Trenton limestone and Calciferour sand rock, and which head in the Laurentian granite of the Adirondacks, have larger flows than those coming to the Mohawk from the south, which lie mostly in the horizon of the Hamilton shales, the headwaters of some of them—as for instance, Schoharie Creek—being in the sandstones of the Chemung and Portage groups. In their lower reaches they cross over the sandstones and shales of the Hudson and Utica groups, with narrow strips of Helderberg limestone, Oriskany sandstone, and Onandaga limestone.

However, there is another consideration. The headwaters of the streams to the north of the Mohawk nearly all lie in a region heavily timbered—some of it is still primeval forest—while those to the south are from a highly cultivated country, practically deforested.

We may now consider the case of Genesee and Oswego rivers, referring to the large geologic map of the State of New York, published in 1894, by James Hall, in cooperation with the U. S. Geological Survey.

Genesee River has an average rainfall of about 40 inches and Oswego River of about 37 inches. That portion of Genesee River which has been gaged lies almost entirely in the shales and sandstones of the Portage and Chemung groups. Oswego River, on the contrary, lies in the horizon of the Portage sandstones and shales, Hamilton shales, Onandaga and Helderberg limestones, Oriskany sandstone, the rocks of the Salina or Salt group, the Lockport limestone, Clinton limestone and shales, Medina sandstones, and Utica sandstones and shales, including the Oswego sandstone. The Chemung, Portage, and Hamilton formations have a wide outcrop, while the Onandaga, Oriskany, and Helderberg are comparatively narrow bands. The Salina, Lockport, Clinton, and Utica formations are all of considerable extent. Both of these streams are practically without forests, although slight exception to this statement may be noted on the extreme headwaters of the Genesee River in Pennsylvania, where there is still a small area of partially cut forest.

It is an interesting circumstance that the geologic formations in which the Genesee and Oneida rivers lie all have a slope to the south or southwest of from 10 to 30 feet per mile. The main trend of the Genesee River is south and north, while the two main branches of Oswego River—Seneca and Oneida—lie east and west. The Mohawk also flows from west to east. On this basis the Portage, Hamilton, Onandaga, Oriskany, Helderberg, and Salina groups lie mostly south of the Seneca and Oneida rivers, while a portion of the Salina, Niagara, Clinton and Medina groups lie mostly to the north. It is interesting, therefore, to speculate as to whether it is possible that considerable water escapes through these formations, finally appearing far to the south, but in the lack of any certain evidence this must be consideerd as merely a speculation.

It may be also noted that for tributaries of the Mohawk River lying to the north, the stratified formations—Utica shales, Trenton group, Calciferous sand rock, etc.—slope toward the stream, and hence may be expected, if there is anything in this view, to deliver more water than that merely due to the rainfall of the catchment as measured on the surface.

On the Upper Mohawk there is some evidence that this is true. The limestones here are open, and at several places streams on the surface sink, to reappear, in one case at any rate, with greatly increased volume several miles farther down. Again, at Howe's cave, in Schoharie County, there is a large stream of water flowing in the cave which, so far as known, does not appear anywhere on the surface.

Moreover, the Muskingum River may be referred to. This stream lies in the unglaciated region in southeastern Ohio, mostly in the horizon of the Conglomerate group of the Carboniferous. The main Muskingum River flows generally from north to south, with its main branches to the east and west, that to the west going a short distance into the Waverly group, which is chiefly sandstone and shale, a subdivision of the Carboniferous. The dip is from west to east. In view of the extremely low run-off of this stream, it seems tolerably evident that there can be no material contribution by percolation through these strata.

As other examples of underground flow, the writer may mention Toyah Creek, in Texas, where a stream of (his recollection is) 40 or 50 cubic feet per second flows from the base of a mountain with no indication as to its source. The well-known streams in Mammoth and Luray caves are doubtless familiar to all. There are also a number of river channels in the West where the water sinks into the porous soils, to reappear at some point lower down; but these are hardly allied to the cases under consideration, because the source is here visible.

A stream at Lausanne, Switzerland, may also be mentioned. In 1872 there was a serious epidemic of typhoid fever at Lausanne, Switzerland, which, on investigation, was found to proceed from a brook irrigating lands about a mile distant from a public well, from which the 800 inhabitants of the village mostly took their water supply. Ten years before, or in 1862, a hole had appeared in the channel of the brook at a certain point, 8 feet deep and 3 feet wide, which disclosed at its bottom a running stream, apparently fed by the brook from a point higher up. The brook itself was led into this hole, with the result that the water all disappeared and in an hour or two streamed out at the public well, showing a connection which had been suspected for years. On refilling the hole the brook returned to its bed.

After the epidemic had ceased in 1872 an investigation was held, the hole was reopened and a large quantity of salt thrown in, its pres-

ence in the public well was easily ascertained by a chemical examination.

This case discloses some points of interest. Here was a considerable stream flowing underground which was easily increased from the water of the brook, which was on the surface. Again, the flow here was through coarse gravel.

In the literature of canal construction there are a number of cases cited in which large losses of water have taken place either through coarse gravel or seamy rocks. Doubtless there are numerous other cases, which, however, are not specially important, for it is the writer's intention only to point out, in a general way, reasons why such losses may sometimes take place.

The outflow from Skaneateles Lake has been cited as showing a large loss, presumably by percolation through strata, but on reference to the original authority it is clear enough that an error has been made in so citing it, because the flow measured was really through 9 miles of natural channel and 8 miles of canal, to Montezuma. It may be mentioned that the problem to be determined by this measurement was the discharge into Seneca River and it is quite possible that there may have been a deficiency from the west.

Skaneateles Lake lies at an elevation of 867 feet above tide water and a distance of about 9 miles south of the Erie Canal, for which it has been used as a feeder since 1844. In 1859 Mr. S. H. Sweet made measurements of the flow to the canal and through the same to Montezuma, where the surplus water is discharged into Seneca River, to which it was found to deliver 125 cubic feet per second. Measurements were also made at the foot of the lake, where the flow amounted to 188 cubic feet per second. The loss was 63 cubic feet per second, or one-third of the whole. Skaneateles Lake itself lies in the Hamilton formation, and its outlet, on its way to the Erie Canal, flows across the Onondaga, Oriskany, Helderberg, and Salina formations. The dip is here from north to south, while the stream, which is tributary to the Seneca River, the main westerly branch of the Oswego, flows from south to north, or in the right direction to realize the maximum possible leakage, or percolation, through the strata. Inasmuch as no such leakage is mentioned, it may be reasonably concluded that none occurred.

Cazenovia Lake and Erieville reservoirs are also mentioned, and considerable loss of water is given, which when analyzed is found to be loss of water in the canal, and hence not in any degree attributable to leakage through strata. Cazenovia Lake and Erieville reservoirs both lie south of the Erie Canal, and flow across substantially the same strata as Skaneateles Lake.[a]

Such facts as these, while lacking the proof of a scientific demon-

[a] Ann. Rept. State Engineer and Surveyor for 1862, pp. 403-404.

stration, are still very interesting and indicate that we have yet much to learn of the peculiarities of stream flow. On the whole, while they undoubtedly point to a moderate loss from percolation, so far as the writer can see they do not indicate any great probability of very large loss from this cause. They do emphasize the fact that every catchment area will have its own formula.

By way of showing that the theory of large evaporation on deforested catchment areas is broadly more reasonable than the theory that there is any great loss of water by seepage owing to inclination of the strata, we may consider the Croton record as given by the appended Table No. 3, where it will be noted that the evaporation from this area is substantially the same as that from Muskingum and Genesee rivers; that is to say, it is the evaporation of a deforested area—the area in forest on this catchment does not exceed 10 per cent. In placing it at 10 per cent the writer means the equivalent in actual effect of dense forest. As regards geologic formation this catchment lies almost entirely in granites and gneisses, in which, from their homogeneous character, it is difficult to assume any loss by percolation through strata. There is, however, a small area of metamorphic Hudson formation, consisting of slate, schist, and quartzite, and also a small area of metamorphic Trenton and Calciferous limestones, but it is exceedingly improbable that any rocks which have been subjected to metamorphic changes are in any degree permeable. This watershed must therefore be considered as underlain by an impermeable formation. All of the water falling upon it except that absorbed by evaporation, chemical changes, etc., reappears as run-off in the streams. It may be safely assumed that there are no other losses. Nevertheless, the evaporation of this stream is that tentatively placed upon other deforested areas. Moreover, there is another interesting consideration of which brief note may be taken at this place. In deference to the water supply department of the city of New York, the writer has used in computing the monthly run-off the catchment area of 338.8 square miles. Mr. Vermeule, however, asserts that this area is not the true one. He says the true area above old Croton dam is 353.1 square miles. If we assume this to be true it follows that the average run-off, instead of being 22.8 inches, is over 4 per cent less, or is, roundly, 21.8 inches. This raises the evaporation from 26.6 inches to 27.6 inches. In his report on forests, Mr. Vermeule has placed the evaporation of his second Croton series, which the writer understands him to consider more reliable, at 22.6 inches, a difference of 5 inches from the foregoing figures, which it may be remarked is based upon the latest revision and is presumably more likely to be correct.

The catchment area of Lake Cochituate may be mentioned. According to Mr. FitzGerald, the slopes of the Cochituate catchment are flat and sandy, with a surface of mostly modified drift. The average rainfall for twenty-nine years, from 1863 to 1891, is 47.1 inches.

the average run-off 20.3 inches, and the evaporation for this period 26.8 inches. This evaporation places it at once in the category of deforested streams. Probably the equivalent of dense forest does not exceed 5 per cent.

The catchment area of Sudbury River has steeper slopes than that of Lake Cochituate and is largely composed of unmodified drift. The rainfall for twenty-six years is 1 inch less than on the Cochituate catchment, and the run-off 2.3 inches larger. The amount of forest does not exceed 6 to 8 per cent. Neshaminy Creek flows from north to south, emptying into the Delaware River not far from Bristol. For several miles its headwaters flow from west to east. Perkiomen Creek flows from north to south, and enters the Schuylkill River about 7 miles above the city of Norristown. Tohickon Creek flows from west nearly due east, although somewhat crooked for a few miles, then flowing in a southwesterly direction it reaches the Delaware River.

The surface of the ground is mostly farm land under a high degree of cultivation. The original forest growth has been almost entirely cut away, and the little remaining timber is found generally on the banks of the creeks, where the hillside is too steep to be cultivated, or on a few patches of bottom land. This growth is mostly composed of hickory, chestnut, oak, and ash. Even this is fast disappearing to supply the ever-increasing demand for railroad ties, fence posts, and rails. The proportion of cultivated lands, woodlands, etc., is as follows: Woodland, about 20 per cent; cultivated land, about 77.5 per cent; roads, 2 per cent, and flats, 0.5 per cent.[a]

On the upper Hudson River, with a catchment above Mechanicville of 4,500 square miles, the average rainfall for the fourteen years from 1888 to 1901, inclusive, was about 44.2 inches, the average run-off 23.3 inches, and the evaporation 20.9 inches. Above Glens Falls this stream lies almost entirely in the pre-Cambrian gneiss, from which it is improbable that there is any loss of water. Its main tributary to the west, Sacandaga, is, by observation, an exceedingly prolific water yielder. To the east, the Battenkill and Hoosic rivers have a different geologic history. The Battenkill flows across the Hudson shales, the Georgia limestones and shales, finally rising in the metamorphic Hudson and Trenton formations. The Hoosic River has a similar geologic history. The run-off of the Hoosic River is, without doubt, considerably less than that of the main Hudson. The average precipitation in western Massachusetts from 1887 to 1895, inclusive, was 38.98 inches, as against 43.29 inches in the northern plateau from 1889 to 1895, inclusive, a difference of 4.31 inches. Should such difference continue, the run-off of Hoosic River might be expected to be, on an average, about 20 inches. Moreover, the Hudson River above Glens Falls (catchment about 2,800 squares miles) is still largely in forest—probably about 85 per cent—but on

[a] Codman, John E., Observations on rainfall and stream flow in eastern Pennsylvania: Proc. Engrs. Club of Phila., Vol. XIV, No. 2, July-Sept., 1897.

the catchments of Wood Creek, Battenkill, and Hoosic rivers the proportion of forest is very much less—as an offhand estimate, the writer would say perhaps 20 to 30 per cent. The run-off of Schroon River, which is perhaps 70 per cent of an equivalent to fairly dense forest, is for four years 26.84 inches. There is, however, some doubt whether this record is entirely reliable, and for the present it is not intended to more than merely call attention to the general proposition that this stream, which issues from an impermeable watershed with 70 per cent of its catchment in forest, has a rather large run-off. The whole catchment area of the Upper Hudson of about 4,500 square miles, will probably not exceed 50 to 60 per cent of forest.

The following are the catchment areas of the several streams here considered: Hoosic, 711 square miles; Battenkill, 438 square miles; Sacundaga, 1,057 square miles, and Schroon River, 570 square miles.

The Pequannock River may also be referred to. This stream is characterized by sharp slopes throughout its whole extent. Its headwaters are at an elevation of about 1,500 feet, while the mouth is only 170 feet above tide. The catchment is about 14 to 16 miles long by 4 to 7 miles wide. Mr. Vermeule states that its headwaters lie in the pre-Cambrian highlands. The sharp slopes, combined with small catchment area, undoubtedly account for the relatively large run-off of this stream. There is also an uncertainty of 1 or 2 inches in the rainfall record. The catchment is judged by the writer to be 70 per cent forest.

In riding over the Pequannock catchment several times the writer was much struck by the fact that aside from the main valleys there are no gulleys throughout this area. The record shows that precipitation is frequently very heavy, but it has been thus far without effect. The indications appear to be that the rainfall, however intense it may be, sinks almost entirely into the ground, and without doubt this peculiarity has its effect on the run-off.

It may be pointed out that the geology of Muskingum and Genesee rivers is substantially the same, while the geology of Croton River and that of Lake Cochituate are entirely different. Nevertheless, when analyzed by aid of the diagrams (figs. 12–16, inclusive), these streams are seen to all have substantially the same evaporation and run-off, although the rainfall on Croton River and Lake Cochituate is different from that of Muskingum and Genesee rivers. Hudson River, however, which has much the same geology as Croton River and Lake Cochituate, has still a very different run-off and evaporation. Oswego River, which lies in a different formation from Genesee River, has still nearly the same evaporation.[a]

These several facts favor the view that deforestation is the real cause of the smaller run-off of Muskingum, Genesee, and Croton rivers and Lake Cochituate.

[a] The evaporation of Oswego River is, in fact, a little greater, due to the existence of large marsh areas on Oswego River.

EFFECTS OF FORESTS.

DO FORESTS INCREASE RAINFALL?

The evidence on this point is conflicting. The variation of the observed from the true rainfall being so great, as has just been shown, the answer to this question must be regarded as very uncertain. It has been discussed by Professor Abbe and Dr. Hough.[a] The following summation by Dr. Hough, although made 26 years ago, may be accepted as expressing the fact at the present day.

> The reciprocal influences that operate between woodlands and climate appear to indicate a close relation between them. It is observed that certain consequences follow the clearing off of forests, which can scarcely be otherwise regarded than as a direct effect, such as the diminution of rivers and the drying up of streams and springs. Other effects, scarcely less certain, are seen in the occurrence of destructive floods, and of unseasonable and prolonged droughts, with other vicissitudes of climate which it is alleged did not occur when the country was covered with forests. These appear to have been brought about by their removal, and might, in a great degree, be alleviated by the restoration of woodlands to a degree consistent with our best agricultural interests.
>
> On the other hand, there are many facts tending to show that the presence or absence and the character of forests are the effect of climate, and that their cultivation generally, or the planting of particular species, is closely dependent upon it. These conditions of climate should be understood before forest cultivation is attempted. It is also to be noticed that differences of opinion have been expressed among men of science as to the extent of influence that forests exert upon the climate, and it is quite probable that the advocates of extreme theories may have erred on both sides. But where principles depend upon facts that may be settled by observation, there should be no differences of opinion; and as there is no fact in this subject that may not be verified or disproved, the existence of such differences only shows the want of accepted evidence derived from trustworthy records.

The interested reader is referred to Dr. Hough's report, which may be easily obtained, for an extended discussion on this point.

EFFECTS OF FORESTS ON RUN-OFF.

The extent of forestation has probably a considerable effect on the run-off of streams. With similar rainfalls, two streams, one in a region having dense primeval forests, the other in a region wholly or partially deforested, will show different run-off. The one with the dense forests will show larger run-off than the stream in the deforested area. In some parts of the State of New York these differences may amount to as much as 5 or 6 inches in depth over the entire catchment area. Yet it must be said that this proposition is, for the present, tentative in its character.

The writer is particular to specify dense forests, because a good deal of discussion has clustered around this point. Of such forests,

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[a] Report upon forestry, by Franklin B. Hough, U. S. Department of Agriculture (1877).

the most effective are those composed of spruce, pine, and other evergreen trees. Where the forest is more or less open to wind and sunshine, its effect, while considerable, is still much less marked than that of dense evergeen forests where the sun seldom penetrates and the wind effect, even in a gale, is only slight. On a catchment area where there are only scattered patches of forest, the effect is practically the same as on a deforested area. The same proposition is generally true on a catchment with young trees. What is wanted for the maximum effect is a mature evergreen forest.

This proposition, however, though definitely stated here, has been nevertheless the subject of considerable discussion, and owing to its complex nature, it is improbable that a final conclusion concerning it will very soon be reached. The writer has discussed this subject in various papers, which may be referred to for details that are mostly omitted here.[a]

WHY THE REMOVAL OF FORESTS AFFECTS STREAM FLOW.

Whatever question there may be as to the influence of forests on rainfall, there is, in the opinion of the writer, none as to such influence on stream flow. Yet this proposition has also been discussed pro and con and is likely to give rise to further discussion, and the conclusion will, therefore, for the present be considered tentative in its character.

It seems to the writer that the removal of forests decreases stream flow by allowing freer circulation of the air and by causing higher temperature and lower humidity in summer and so producing greater evaporation from water surfaces, as well as from the ground.

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[a] The following reports and papers are cited:

1. Three reports on Genesee River storage surveys: Appendixes to Ann. Repts. State Engineer and Surveyor for 1893, 1894, and 1896.

2. Two reports on Upper Hudson storage surveys: Appendixes to Ann. Repts. State Engineer and Surveyor for 1895 and 1896.

3. Water supply of the western division of the Erie Canal: Ann. Rept. State Engineer and Surveyor for 1896.

4. The economics of the Hudson River; lecture before the engineering classes of Rensselaer Polytechnic Institute, Feb. 24, 1897.

5. Stream flow in relation to forests: Proc. Am. Forestry Association, Vol. XII, 1897; also, reprint in Ann. Rept. Fisheries, Game and Forest Commission (1896), published in 1898. Reprint, 1898.

6. Natural and artificial forest reservoirs of the State of New York: Third Ann. Rept. Fisheries, Game, and Forest Commission (1897), published in 1899. Reprint, 1899.

7. Water Resources of the State of New York, Parts I and II: Water-Supply and Irrigation Papers U. S. Geol. Survey, Nos. 24 and 25, 1899.

8. On the application of the principles of forestry and water storage to the mill streams of the State of New York: Proc. Twenty-second Ann. meeting of Pulp and Paper Association. (1899.)

9. Indian River dam, by Geo. W. Rafter, Wallace Greenalch, and Robert E. Horton: Engineering News, May 18, 1899. Reprint, 1899.

10. Data of stream flow in relation to forests; lecture before engineering classes of Cornell University, April 14, 1899: Trans. Association of Civil Engineers of Cornell University, Vol. VII, 1899. Reprint, 1899.

11. A report on a water supply from the Adirondack Mountains for the city of New York: Appendix E of an inquiry into the conditions relating to the water supply in the city of New York by the Merchants' Association, 1900.

12. Report to the Board of Engineers on deep waterways, on the water supply of enlarged canals through the State of New York; Appendix 16, pp. 571-950. (1901.)

That the removal of forests renders stream flow less equal throughout the year and so causes floods and periods of dryness in rivers seems to be beyond reasonable question, for the forest litter and root masses serve as storage reservoirs, tending to equalize the flow of streams.

Space will not be taken to discuss these propositions, because very little can be added to previous discussions. The reader is referred to the Bulletin No. 7, of the Forestry Division of the Department of Agriculture on Forest Influences, as well as to Dr. Hough's report on forests, for fairly complete discussions.

FORESTATION OF THE CROTON CATCHMENT AREA.

In a paper[a] read before the American Forestry Association in 1901, Mr. Vermeule proposes the question whether the forestation of the catchment area of the Croton water supply is advisable. In considering this question it may be pointed out that if the Croton watershed were forested, there is no probability of reaping the full benefit under from 75 to 150 years. On this point the following statement by Mr. B. E. Fernow, director of the New York State College of Forestry, at Cornell University, is pertinent:[b]

> The one thing in which the forestry business differs from all other business is the long-time element, for it takes 100 years and more to grow trees fit for the use of the engineer, the builder, and the architect; hence the dollar spent now in its first start must come back, with compound interest, 100 years hence.

For the sake of the argument, we will assume that on this watershed in 120 years the full effect of forestation would be realized. This would give, as an average, an increase of from 4 to 6 inches in run-off. For the purposes of this discussion we may assume it at 5 inches.

In order to forest the watershed it would be necessary to acquire the entire area, which, so far as the writer can ascertain, could hardly be done for less than $100 per acre. Probably the price would be much greater than this, but to avoid an overestimate it may be fixed at $100 per acre. At this rate the catchment area of 339 square miles would cost $21,696,000. The planting out of trees could hardly cost less than $20 per acre additional, but in order to make the estimate as reasonable as possible we will take it at $10 per acre, which makes an additional sum of $2,169,900, or a total of $23,865,900.

If we assume the annual interest at 3 per cent, and place this sum at compound interest for 120 years, we have at the end of that time the sum of $779,510,000. The present safe yield of the Croton watershed, with all available storage, is about 280,000,000 gallons per day. We would pay, therefore, this large sum for, perhaps, 75,000,000 gallons additional per day at the end of 120 years. It is true, there

[a] New Jersey forests and their relation to water supply, by C. C. Vermeule: The Engineering Record, Vol. XLII, No. 1 (July, 1901).

[b] The forester an engineer, by B. E. Fernow: Jour. Western Soc. Engrs., Vol. VI, No. 5 (Oct., 1901).

would be some increase in water supply after about 30 years, and the supply might be expected to go on increasing until the average increase of yield was attained in 120 years. But the increase in water supply would not be at all commensurate with the increase of capitalization. It is very evident that an expenditure of this sum of money would procure a far greater quantity of water from other sources. Hence it does not seem expedient to suggest the forestation of the Croton catchment area.

Another objection to the forestation of the Croton watershed as a remedy for the water difficulties of New York City may be found in the fact that a considerably increased water supply is wanted at once; it is entirely out of the question to wait 120 years for such increased supply.

As a broad proposition, however, catchment areas from which municipal water supplies are drawn should be in forests, and undoubtedly as time goes on this condition will be more and more attained. Already various European and American municipalities have recognized the advisability of owning the catchments from which their municipal water supplies are drawn.

DETAILS CONCERNING TABLES AND DIAGRAMS.

TOPOGRAPHIC RELATIONS OF CATCHMENT AREAS OF STREAMS TABULATED.

The following gives an outline of the topography of the several catchment areas included in the tables.

The headwaters of Muskingum River lie at an elevation of about 1,100 feet, and it flows into the Ohio River, near Marietta, at an elevation of about 500 feet. The Muskingum River proper has a length of 109 miles, with its main tributaries, the Walhonding and the Tuscarawas, having an additional length of about 100 miles, thus giving the basin a length of 200 miles. From the head of the Tuscarawas to the junction of the two main tributaries there is a fall of about 2 feet per mile, and from this point to the mouth of the main Muskingum the descent is about 1.5 feet per mile. On the Walhonding the descent is more rapid. At its headwaters, near Mansfield, the stream is from 400 to 450 feet above what it is at its junction with the Tuscarawas.

The Genesee River rises in Potter County, Pa., and flows in a northerly direction across the State of New York, emptying into Lake Ontario at Rochester, having a total length of about 115 miles. Its headwaters are at an elevation of over 2,000 feet, while Lake Ontario lies at a mean elevation of 247 feet. This stream is specially characterized by two sets of falls. The three falls at Portage have an aggregate of about 270 feet, while at Rochester the river falls 263 feet, also in three falls, with some intervening rapids. This stream flows for several miles at Rochester and Portage over bare rocks.

The Croton River flows into the Hudson at Croton Landing at an elevation of practically tide water. Its extreme headwaters in Dutchess County are at an elevation of about 700 feet above tide. Its length is about 35 miles.

Lake Cochituate is in a generally flat area at an elevation of about 200 feet above tidewater. A small area in the south portion rises to an elevation of 300 feet. The greatest extent of this area is from northeast to southwest, about 9½ miles, with an average width of about 2 miles. In the northern part it is narrower than this and in the southern somewhat greater.

Sudbury River catchment area lies immediately to the west of the Lake Cochituate catchment. The elevations vary from about 200 feet above tide to from 500 to 600 feet. Its length from north to south is about 10 miles, and from east to west about 8 miles. Owing to a number of hills throughout the area the slopes are much steeper than on the Cochituate catchment. Sudbury catchment lies about 25 miles to the west of Boston.

Mystic Lake is practically at sea level, with considerable hills in a portion of the catchment area. The slopes are steep, but not quite as steep as Sudbury.

Neshaminy Creek flows into the Delaware River at an elevation of from 10 to 20 feet above tide water. Its headwaters are at an elevation of about 300 feet. Its extreme length from north to south is from 40 to 45 miles.

Perkiomen Creek flows into the Schuylkill at an elevation of about 75 feet above tide level. The headwaters are at an elevation of 550 feet. The length of the basin from north to south is about 30 miles.

Tohickon Creek flows into the Delaware River at an elevation of about 70 feet above tide. Its extreme headwaters are at an elevation of 525 feet. Its length, from east to west, is about 25 miles.

Hudson River, at Mechanicville, is about 60 feet above tide, while at its extreme headwaters it is about 3,400 feet above tide level. The catchment area above Glens Falls is from 40 to 50 miles from east to west and from 60 to 65 miles from north to south. Below Glens Falls the catchment extends well into southern Vermont and Massachusetts. The length of the stream above Mechanicville is from 120 to 125 miles.

Pequannock River flows into the Passaic near Pompton, at an elevation of 170 feet above tide. The main facts of the topography of this stream have been given in the chapter on "The relation of geology to the run-off of streams."

The Connecticut River flows into Long Island Sound at tide water, and rises in the northern part of New Hampshire. Its extreme headwaters issue from an elevation of 2,000 to 3,000 feet above tide level. Its length is about 375 miles. The topography of this catchment is hilly and, in the northern part, mountainous.

CLASSIFICATION OF STREAMS.

In Table No. 13 we have the mean rainfall, run-off, and evaporation of the storage, growing, and replenishing periods of the streams for which individual figures are given in Tables Nos. 1 to 12, inclusive. This table shows what may be termed the family resemblance between streams. For instance, for the Muskingum and Genesee rivers the mean rainfall of the storage period is about 19 inches, with a run-off of about 10 inches and an evaporation of about 9 inches. For the growing period the mean rainfall of each of these two streams is about 12 inches, with run-off 1.7 inches and evaporation 10 inches. For the replenishing period the mean rainfall of each is about 9 inches, with run-off about 2 inches and evaporation 7.5 inches. The total rainfall of the whole year is 40 inches for each stream—run-off 13.5 inches and evaporation 26.5 inches.

The Croton River has a much higher rainfall. Twenty-four inches in the storage period produces 17 inches of run-off, with an evaporation of 7 inches. From 13.6 inches of rain in the summer we have 2.6 inches of run-off, with 11 inches of evaporation. The rainfall for the year is 49.4 inches, or, say, 9 inches more than for Muskingum and Genesee rivers. The run-off is also about 9 inches in excess of that of these two streams. The evaporation is, however, the same, pointing very strongly to a similar cause.

On Lake Cochituate catchment 23.1 inches rainfall in the storage period produces on an average but 14.9 inches of run-off, with 8.2 inches of evaporation. The rainfall of the growing period is the same as that of the Muskingum and Genesee rivers, yielding, however, 2.1 inches run-off and 9.5 inches evaporation. For the replenishing period, 12.4 inches rainfall yields 3.3 inches run-off, with 9.1 inches evaporation. The totals for the year are, rainfall, 47.1 inches; run-off, 20.3 inches, and evaporation, 26.8 inches. Aside from difference in catchment areas, the total evaporation of both Croton River and Lake Cochituate is substantially the same as that of Muskingum and Genesee rivers. The excess rainfall of Lake Cochituate over Muskingum and Genesee rivers is about the same as the excess evaporation; that is to say, 7.5 inches. As regards evaporation, Lake Cochituate may therefore class with the Muskingum, Genesee, and Croton rivers.

For Sudbury River, Mystic Lake, Neshaminy and Perkiomen creeks, somewhat different conditions prevail. The yearly evaporation is here about 24 inches, and, with the exception of Mystic Lake, the run-off is about 23 inches. On Mystic Lake catchment the rainfall is enough smaller to fully account for the difference in run-off. Broadly, these four streams may be considered as making a second class.

Tohickon Creek has a total annual mean rainfall of 50 inches, from whence it results that the mean yearly run-off is 28.4 inches and the

evaporation 21.7 inches. This stream varies so much, from what the general principles indicate, that the writer doubts somewhat the correctness of the record. He considers it quite possible that it may be 10 per cent to 20 per cent in error. Reasons for this view are given in the chapter on "Negative evaporation." The writer recognizes, however, that in view of the uncertainty of gagings, etc., the mere fact of a stream not squaring with preconceived views ought not to condemn its record. There must be valid reasons for rejecting the particular record.

The Hudson River shows apparently the effect of an impermeable catchment, combined with a large forest area. It has a mean annual rainfall of 44.2 inches, yielding 23.3 inches run-off, with 20.9 inches evaporation. For the storage period 20.6 inches rainfall yields 16.1 inches run-off, with 4.5 inches evaporation. For the growing period 12.7 inches rainfall yields 3.5 inches run-off, with 9.3 inches evaporation. For the replenishing period 10.9 inches rainfall yields 3.7 inches run-off and 7.1 inches evaporation. This stream, from general similarity, may properly classify with the Connecticut.

For the Pequannock River explanations have already been given, which apply generally. For the present it tentatively stands in a class by itself.

The classification here given is experimental merely, and is subject to modification with the gathering of more complete data.

DESCRIPTION OF TABLES NOS. 1 TO 12.

Table No. 1 gives the rainfall, run-off, and evaporation of the storage, growing, and replenishing periods, as well as the total of these three items, on the Muskingum River, for the years 1888–1895, inclusive. The minimum year was 1895, the total run-off being 4.90 inches. The maximum occurred in 1890, with a total run-off of 26.84 inches. The mean run-off for the entire period is 13.1 inches.

Table No. 2 gives the same facts for the Genesee River for the years 1890–1898, inclusive. In this table, for the years 1890–1892, the record of Oatka Creek, which was gaged by the writer, has been used. For a portion of 1893, the results are computed. The dam at Mount Morris, at which gagings were taken, was carried away by a flood early in 1897, and for the years 1897 and 1898 the gaging record has been deduced by comparison of the rainfalls with those at Rochester, where gagings are kept by the city engineer. The results, aside from those for the years 1894–1896, must be considered somewhat approximate, although probably within 10 per cent of the truth. The mean evaporation for the years 1894–1896 was 27.21 inches.

Table No. 3 exhibits the rainfall, run-off, and evaporation of the storage, growing, and replenishing periods for Croton River, from 1868–1899, inclusive, a period of thirty-two years. This record has

been revised as per experiments at Cornell University, described by John R. Freeman, member American Society Civil Engineers, in his report to the comptroller in 1900. As shown by Mr. Freeman, the rainfall record from 1868–1876, inclusive, is not very reliable, and accordingly two sets of means are given. The mean rainfall from 1868–1876, inclusive, was 45 inches, the mean run-off 23.37 inches, and the mean evaporation 21.63 inches. For the second period the rainfall from 1877–1899, inclusive, has been so rationally treated by Mr. Freeman as to leave nothing to be desired. The means for this second period are: rainfall, 49.33 inches; run-off, 22.81 inches, and evaporation, 26.52 inches. A comparison of these two sets of means shows how dangerous it is to draw final conclusions from data about which there is considerable doubt. The rainfall differs by 4.33 inches and the evaporation by 4.89 inches, or from 20 per cent to 25 per cent.

In preparing this table the figures of table No. 26 of Mr. Freeman's report have been used. This table is in million gallons per 24-hour day, and has been reduced to inches per month on the catchment area of 338.8 square miles. The following gives the water surfaces exposed to evaporation at different periods:

	Per cent.
5.8 square miles, 1868–1873,	= 1.73
6.2 square miles, 1873–October, 1878,	= 1.83
6.9 square miles, 1878–1891,	= 2.03
8.4 square miles, 1891–1893,	= 2.48
9.5 square miles, 1893–1895,	= 2.82
11.0 square miles, 1895–1897,	= 3.28
12.0 square miles, 1897–1900,	= 3.56

It may at first thought be imagined that these large water sufaces exposed to evaporation have considerably increased the ground evaporation over the entire catchment. When, however, one considers that it is only the difference between what a water-surface evaporation and what a ground-surface evaporation would be, the difference is seen to be not very much. For instance, assuming the water-surface evaporation at 36 inches per year and the ground-surface evaporation at 27 inches per year, the difference becomes 9 inches. With 12 square miles of water surface in 1900, giving 3.56 per cent of the whole, the excess of water-surface evaporation over ground-surface evaporation is 0.32 of an inch, a quantity which is so far within the limit of possible error in other directions as to be negligible. At the most, taking the assumed catchment area at 338.8 square miles, it would only reduce the evaporation from 26.5 inches to 26.2 inches.

The minimum year in this table is seen to be 1880, when only 13.71 inches ran off. In 1883 the run-off was also very low, being only 13.74 inches.

Table No. 4 exhibits a similar set of facts for Lake Cochituate from 1863–1900, inclusive. Two sets of means are also given in this case,

one from 1896–1900, a period of 5 years, and the other from 1863–1900, a period of 38 years. There is very little difference between these two sets of means. The minimum year is seen to have been 1883, when there was only 10.09 inches of run-off.

Table No. 5 gives the same data for Sudbury River from 1875–1900, inclusive, a period of 26 years. Two sets of means, one for the five years from 1896–1900, inclusive, and the other for the entire period of 26 years, are also given in this case. The catchment area of this stream is hilly, and considerable variation in rainfall may be expected to take place. Originally only one rain gage was exposed, but latterly there are several, and the rainfalls as given in the table are the means of these. In 1883, which was the year of minimum run-off, only 11.40 inches appeared in the stream, out of a total precipitation of 31.52 inches.

According to the Sixth Annual Report of the Metropolitan Water Board, rainfall observations for Sudbury catchment were taken as follows: January, 1875, to April, 1876, Lake Cochituate only; April to June, 1876, Lake Cochituate, Westborough, and Hopkinton; June to December, 1876, Lake Cochituate, Southborough, Marlborough, Westborough, and Hopkinton; December, 1876, to January, 1883, Framingham, Southborough, Westborough, Marlborough, and Hopkinton; January, 1883, to January, 1884, Framingham and Southborough; January, 1884, to January, 1890, Framingham and Westborough; January, 1890, to May, 1898, Framingham and Ashland dam; June, 1898, to December, 1900, Framingham, Ashland dam, Cordaville, and Sudbury dam.

The catchment area of Sudbury River, from 1875–1878, inclusive, was 77.764 square miles; in 1879 and 1890 it was 78.238 square miles, and from 1881–1900, inclusive, 75.2 square miles.

On Sudbury catchment water surfaces were 1.9 per cent of the whole from 1875–1878, inclusive; they were 3 per cent in 1879, 3.4 per cent in 1885, 3.9 per cent in 1894, and 6.5 per cent in 1898. The catchment also contains extensive areas of swamp land, which, although covered with water at times, are not included in the above percentages of the water surfaces.

Table No. 6 gives the rainfall, run-off, and evaporation of the storage, growing, and replenishing periods for Mystic Lake catchment, from 1878–1895, inclusive, a period of 18 years. The minimum year, with a total run-off of 9.44 inches, occurred in 1883. Since it is the run-off of the minimum year which determines the value of a stream for water supply, this figure shows that this stream is not, on the whole, as good a water yielder as Lake Cochituate and Sudbury catchments.

Table No. 7 gives the rainfall, run-off, and evaporation of the storage, growing, and replenishing periods for Neshaminy Creek for the

years 1884–1899, inclusive, a period of 16 years. The minimum year was 1895, when, with a rainfall of 38.59 inches, 18.15 inches ran off. Neshaminy Creek may be taken as a deforested area.

Table No. 8 gives for Perkiomen Creek the rainfall, run-off, and evaporation of the storage, growing, and replenishing periods for the 16 years from 1884–1899, inclusive. The minimum year was 1895, when, with 40.35 inches rainfall, the run-off was 17.58 inches. The writer's recollection is that in riding through this area some time ago, the forest is mostly scattered and is probably equivalent in effect to not more than 8 per cent to 10 per cent of dense forest. If he is wrong in this, he will be glad to be set right.

Table No. 9 gives for Tohickon Creek the rainfall, run-off, and evaporation of the storage, growing, and replenishing periods from 1884–1898, inclusive, a period of 15 years. The year of minimum run-off was 1896, when 48.03 inches of rainfall yielded 19.73 inches of run-off. The rainfall of this catchment is considerably higher than that of the two contiguous streams, from whence it results that the run-offs are also larger.

Table No. 10 gives the rainfall, run-off, and evaporation of the storage, growing, and replenishing periods for the Hudson River area for a period of 14 years, from 1888–1901, inclusive. The minimum year was 1895, when 36.67 inches of rainfall yielded 17.46 inches as run-off in the stream.

Table No. 11 gives the rainfall, run-off, and evaporation of the storage, growing, and replenishing periods of the Pequannock River catchments for 9 years, from 1891–1899, inclusive. The minimum year was 1895, when, with 37.92 inches of rainfall, 21.11 inches appeared as run-off. The rainfall record for this catchment area is not entirely satisfactory and further study may modify it somewhat.

Table No. 12 gives the rainfall, run-off, and evaporation of the storage, growing, and replenishing periods for the Connecticut River at Hartford for a period of 14 years, from 1872–1885, inclusive. The minimum year was 1883, when, with 32.55 inches of rainfall, 12.61 inches ran off. The record, however, of the year 1883 is that of Holyoke, Mass., the years 1882 and 1883 not being given in Mr. Babb's paper, from which these data are otherwise taken. For these years the rainfall has been computed and is, of course, approximate.

Moreover, the record of Connecticut River as a whole can not be deemed very satisfactory, either as regards the rainfall or the run-off. The run-off is probably anywhere from 5 per cent to 20 per cent in excess and a considerably larger number of stations should be averaged to give safe rainfall. The record at Holyoke from 1880–1899, inclusive, is considered much more satisfactory, but unfortunately this record is not accompanied by the rainfall, and thus far the writer has not had an opportunity to obtain these.

DESCRIPTION OF DIAGRAMS

We may now consider a few of the large number of diagrams which have been prepared.

Fig. 1 shows, for the Upper Hudson, precipitation, evaporation, run-off, and mean annual temperature for the years 1888–1890, inclusive, plotted in the natural order.

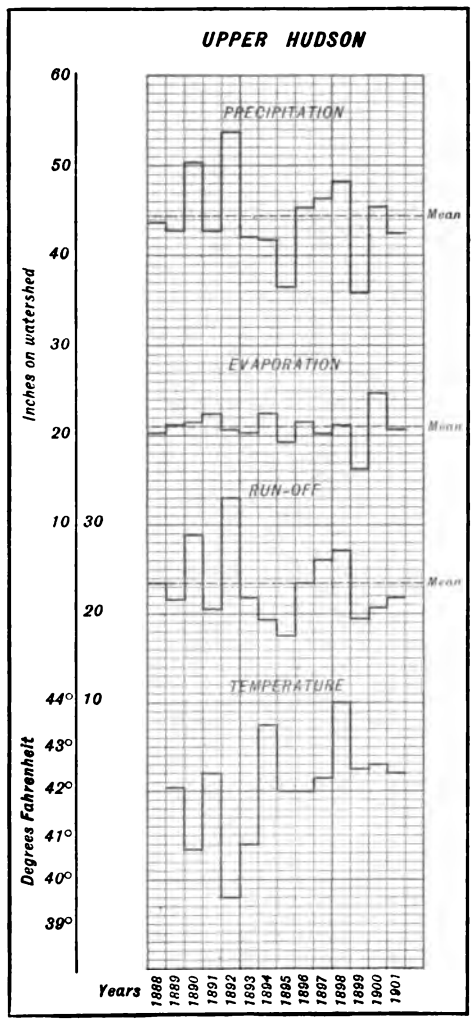

FIG. 1.—Diagram showing relation between precipitation, evaporation, run-off and temperature on the Upper Hudson River.

Fig. 2 shows, for the same area, evaporation and mean annual temperature, plotted in the order of the evaporation.

Fig. 3 shows, for the Upper Genesee, precipitation, evaporation, run-off, and mean annual temperature, plotted in the order of the precipitation.

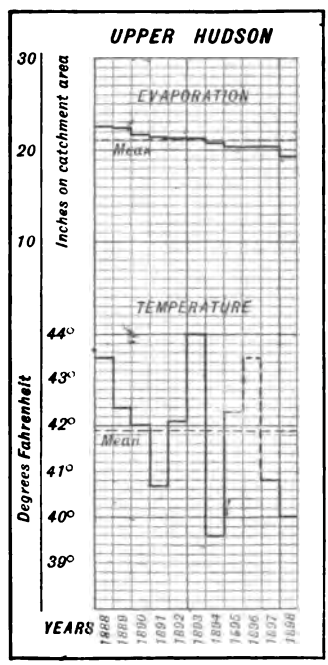

FIG. 2.—Diagram showing the relation between evaporation and temperature on the Upper Hudson River, the years being arranged according to the amount of evaporation.

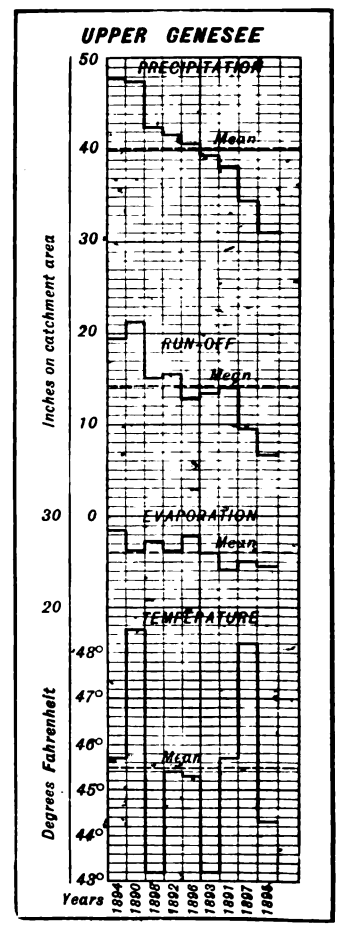

FIG. 3.—Diagram showing the relation between precipitation, run-off, evaporation, and temperature on the Upper Genesee River, the years being arranged in order of dryness.

Fig. 4 shows, for Sudbury River, precipitation, evaporation, run-off, and mean annual temperature, plotted in the natural order.

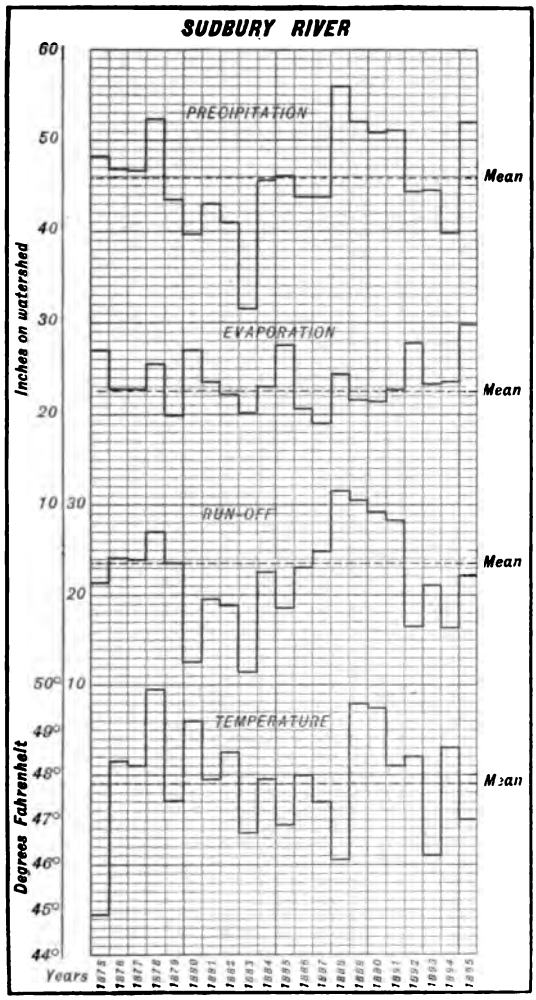

FIG. 4.—Diagram showing the relation between precipitation, evaporation, run-off, and temperature on the Sudbury River, Massachusetts.

On fig. 5 we have, for the same stream, precipitation, evaporation, run-off, and mean annual temperature, plotted in the order of the precipitation.

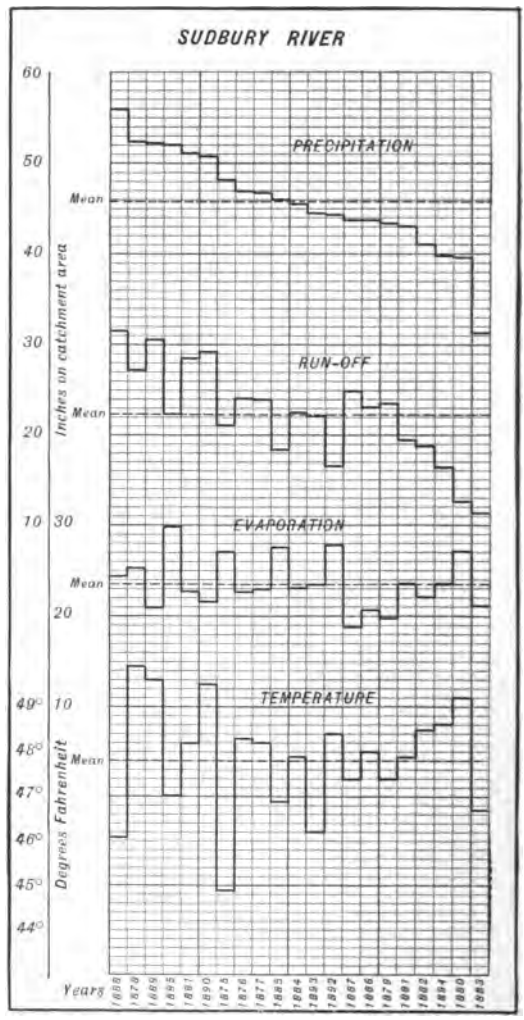

FIG. 5.—Diagram showing relation between precipitation, evaporation, run-off, and temperature on the Sudbury River, Massachusetts, the years being arranged in order of dryness.

On fig. 6 we have, also for Sudbury River, evaporation and mean annual temperature, plotted in the order of the evaporation.

Fig. 7 shows, for the Muskingum River, precipitation, evaporation, run-off, and mean annual temperature, plotted in the order of the precipitation.

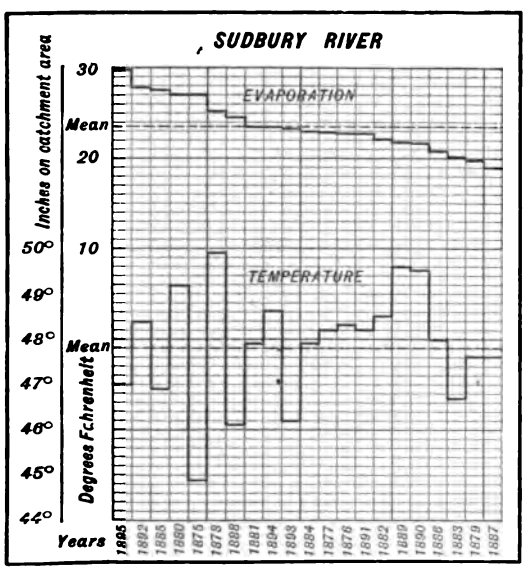

FIG. 6.—Diagram showing the relation between evaporation and temperature on the Sudbury River, the years being arranged according to the amount of evaporation.

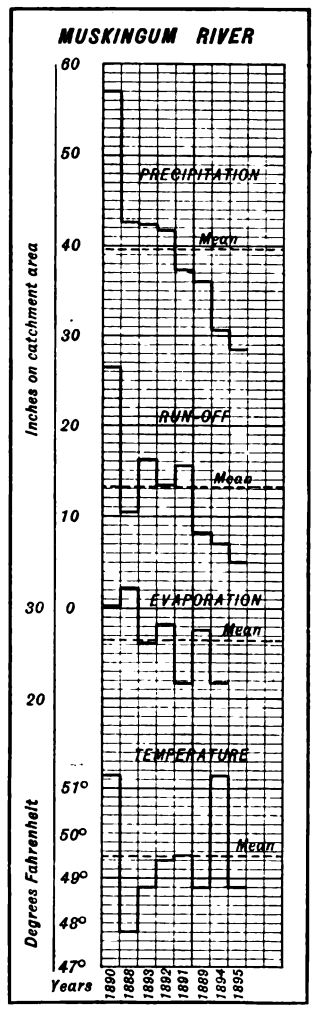

FIG. 7.—Diagram showing the relation between the precipitation, run-off, evaporation, and temperature on the Muskingum River, Ohio, the years being arranged in order of dryness.

Fig. 8 shows, for Lake Cochituate, precipitation, evaporation, run-off, and mean annual temperature, plotted in the order of the precipitation.

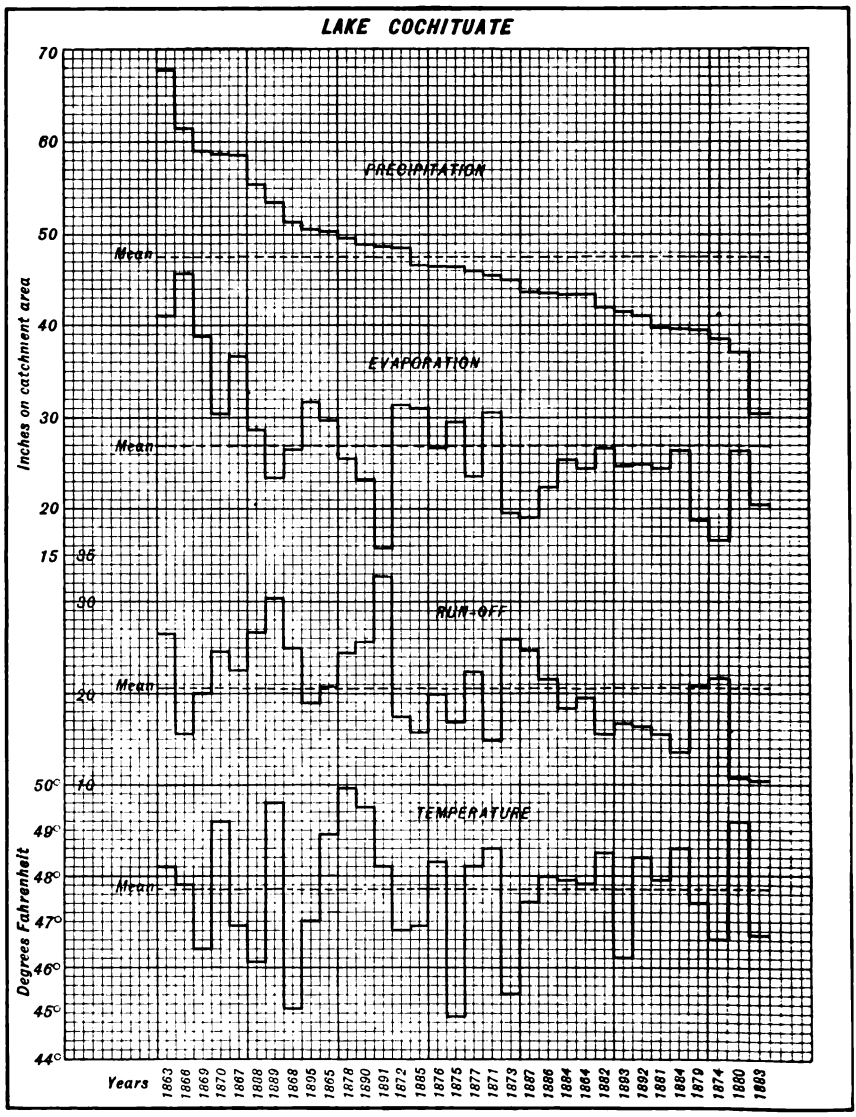

FIG. 8.—Diagram showing the relation between the precipitation, evaporation, run-off, and temperature in the Lake Cochituate Basin, the years being arranged in order of dryness.

Fig. 9 shows, for Lake Cochituate, evaporation and mean annual temperature, plotted in the order of the evaporation.

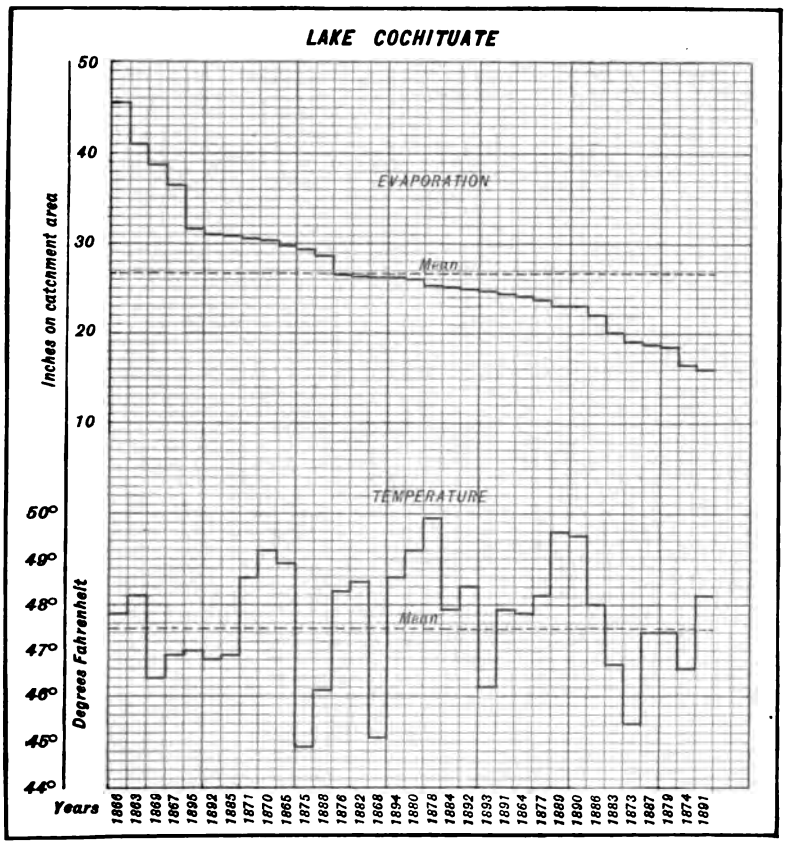

FIG. 9.—Diagram showing the relation between evaporation and temperature in the Lake Cochituate Basin, the years being arranged according to the amount of evaporation.

On fig. 10 the relation between precipitation and run-off, for the Upper Hudson, has been expressed by the formula $P^2=84.5\ R$. These diagrams (figs. 1 to 10) all show, together with many others not here published, that there is no definite relation between evaporation and mean annual temperature.

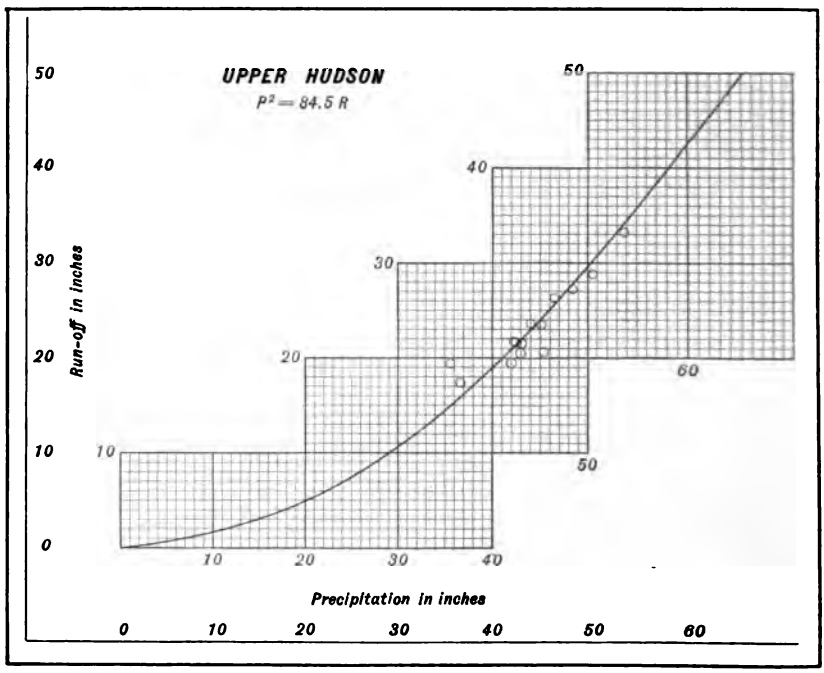

FIG. 10.—Diagram showing the relation between the precipitation and run-off in inches on the Upper Hudson River.

EXPONENTIAL FORMULA.

On fig. 11 this relation is expressed by an exponential formula, after the manner proposed by Mr. FitzGerald in his paper, "Flow of water in 48-inch pipes."[a] Such a curve has the advantage that it is the best approximation possible to obtain from the given data. It will be noticed that it differs slightly from the curve of fig. 10. At 30 inches rainfall this difference amounts to about 1.3 inches of run-off.

While on the subject of exponential formulas it may be remarked that their chief advantage lies in the possibility of taking any set of data and deducing the curve which best suits the conditions.

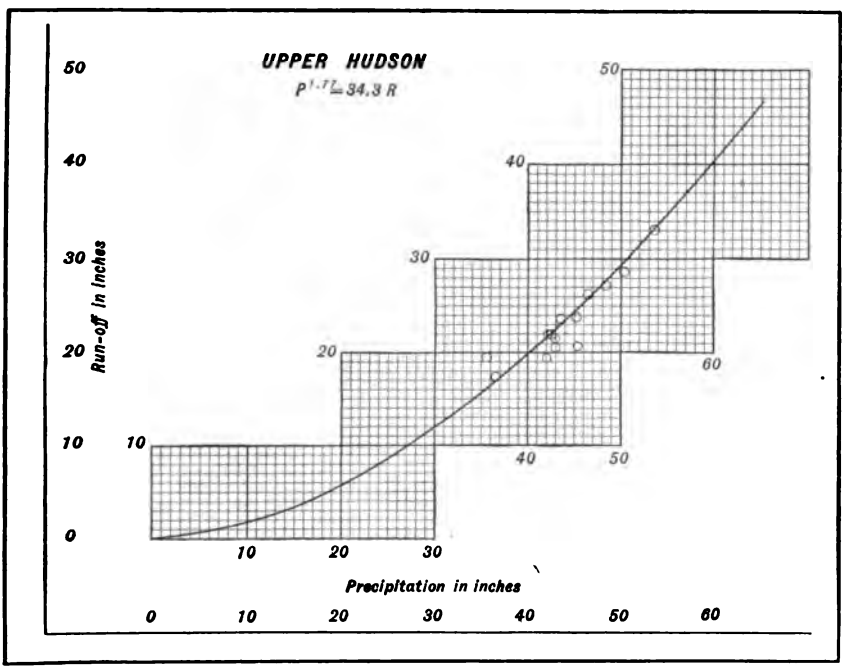

FIG. 11.—Diagram showing the relation between the precipitation and run-off in inches on the Upper Hudson River, expressed by exponential formula.

DESCRIPTION OF RUN-OFF DIAGRAMS.

Fig. 12 is a run-off diagram of Hudson and Genesee rivers, Hudson River for 1888-1901, inclusive, and Genesee River for 1890-1898,

[a] Trans. Am. Soc. C. E., Vol. XXXV, p. 241.

inclusive. In preparing this and the following diagrams it is considered that if both run-off and precipitation were correctly measured the points would fall in a regular curve approximately like those shown on figs. 10 and 11. Such diagrams may therefore be taken as a criterion of the accuracy with which the observations have been made. It is easier, however, to measure the run-off than it is to measure the precipitation, and hence when large variation occurs, as it does in these several diagrams, we may first look for it in the precipitation records. As regards the Hudson area, it has been the writer's custom to take the rainfall of the northern plateau of the State weather bureau as, on the whole, best representing the rainfall of the Upper Hudson area. With the exception of the years 1899 and 1900 the points all fall within from an inch to an inch and a half of the curve. Those two years have, however, been computed by a less accurate method than the preceding ones. It is concluded, therefore, that aside from 1899 and 1900 the curves represent the rainfall and run-off of Hudson and Genesee rivers with considerable accuracy.

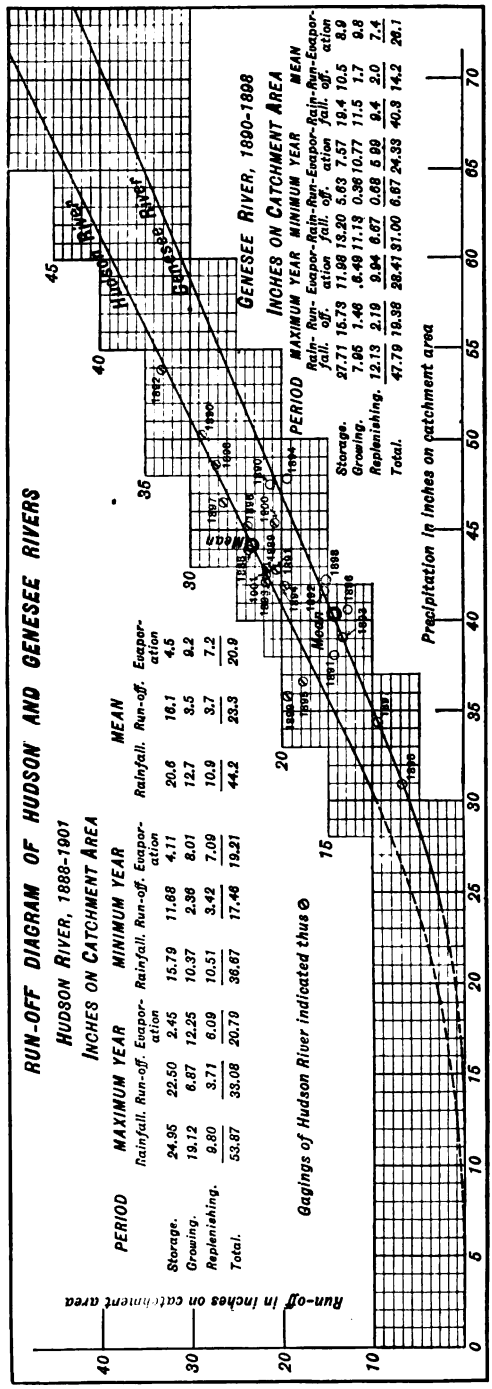
RUN-OFF DIAGRAM OF HUDSON AND GENESEE RIVERS
HUDSON RIVER, 1888-1901
INCHES ON CATCHMENT AREA
PERIOD MAXIMUM YEAR MINIMUM YEAR MEAN
Rainfall. Run-off. Evaporation Rainfall. Run-off. Evaporation Rainfall. Run-off. Evaporation
Storage. 24.95 22.50 2.45 15.79 11.68 4.11 20.8 16.1 4.5
Growing. 19.12 6.87 12.25 10.37 2.36 8.01 12.7 3.5 9.2
Replenishing. 9.80 3.71 6.09 10.51 3.42 7.09 10.9 3.7 7.2
Total. 53.87 33.08 20.79 36.67 17.46 19.21 44.2 23.3 20.9
Gagings of Hudson River indicated thus ⊙
GENESEE RIVER, 1880-1898
INCHES ON CATCHMENT AREA
PERIOD MAXIMUM YEAR MINIMUM YEAR MEAN
Rain-fall. Run-off. Evapor-ation Rain-fall. Run-off. Evapor-ation Rain-fall. Run-off. Evapor-ation
Storage. 27.71 15.79 11.98 13.20 5.63 7.57 19.4 10.5 8.9
Growing. 7.95 1.46 6.49 11.13 0.36 10.77 11.5 1.7 9.8
Replenishing. 12.13 2.19 9.94 6.67 0.68 5.99 9.4 2.0 7.4
Total. 47.79 19.38 28.41 31.00 6.67 24.33 40.3 14.2 26.1
Precipitation in inches on catchment area
Run-off in inches on catchment area
Hudson River
Genesee River

FIG. 12.—Run-off diagram of Hudson and Genesee rivers.

Fig. 13 shows in a similar manner a run-off diagram for Muskingum River from 1888 to 1895, inclusive.

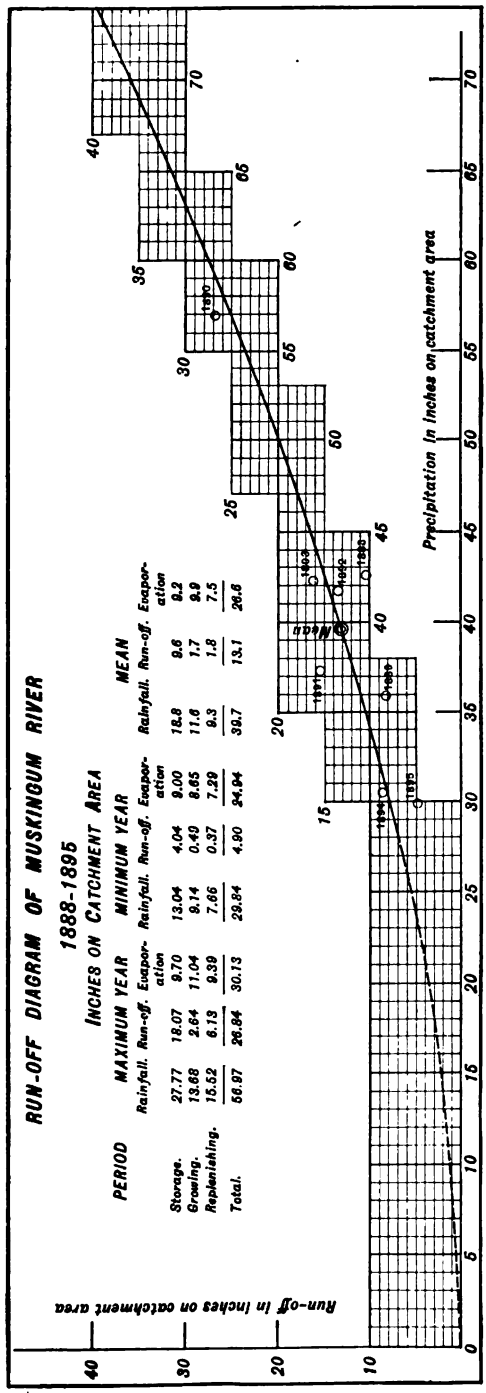

FIG. 13.—Run-off diagram of Muskingum River.

Fig. 14 is a similar diagram for Passaic River from 1877 to 1893, inclusive.

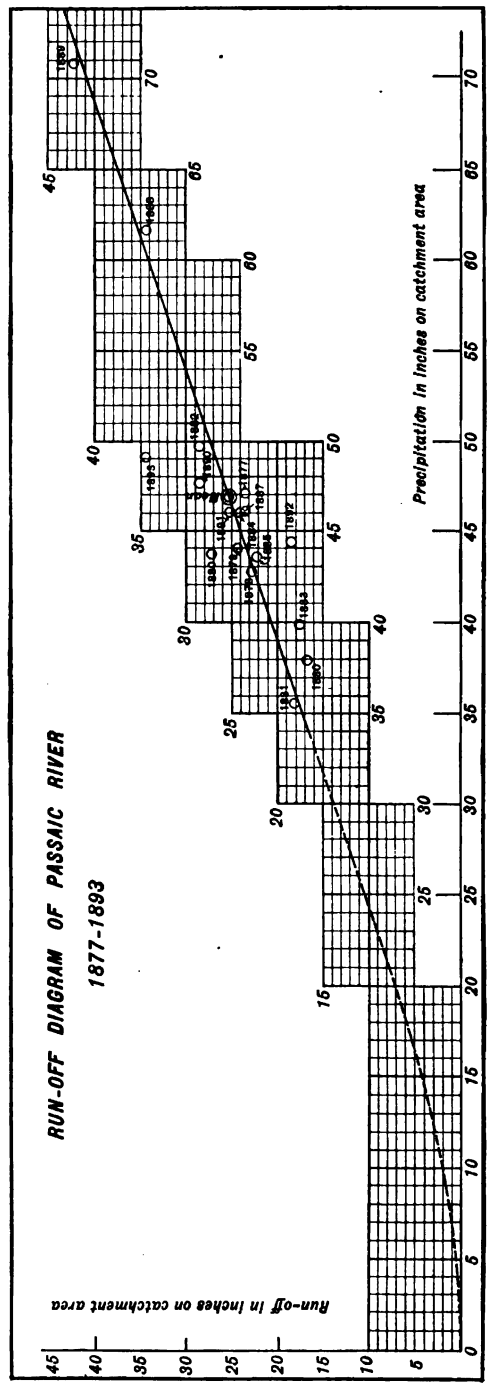
RUN-OFF DIAGRAM OF PASSAIC RIVER
1877-1893
Run-off in inches on catchment area
Precipitation in inches on catchment area

FIG. 14.—Run-off diagram of Passaic River.

Fig. 15 is a similar diagram of Sudbury River from 1875 to 1900, inclusive.

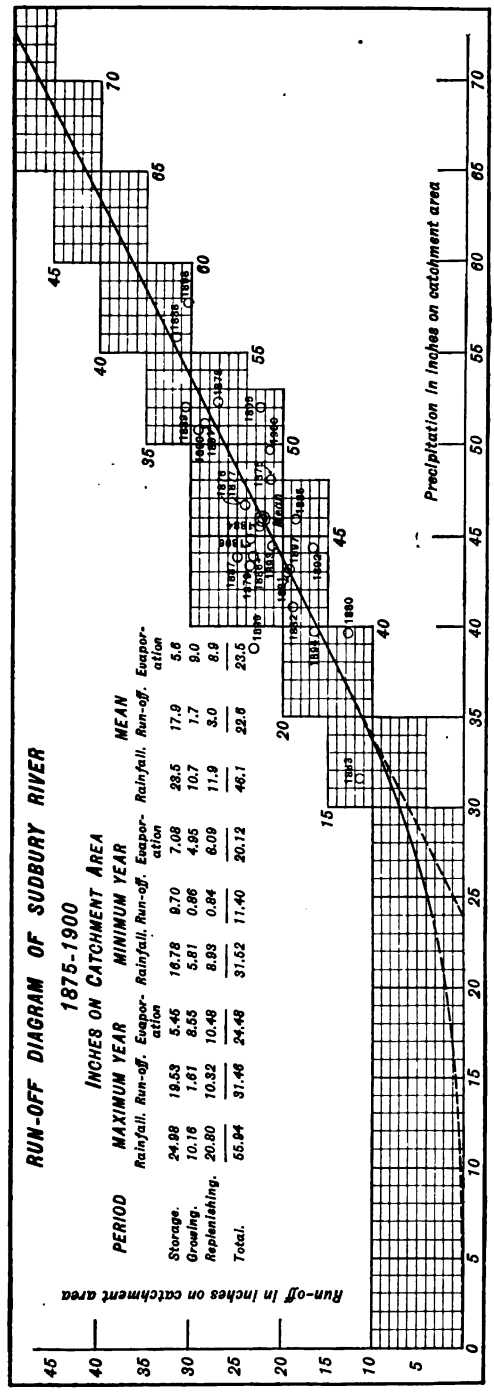
RUN-OFF DIAGRAM OF SUDBURY RIVER
1875-1900
INCHES ON CATCHMENT AREA
PERIOD
MAXIMUM YEAR
MINIMUM YEAR
MEAN
Rainfall. Run-off. Evaporation
Storage. 24.98 19.53 5.45 16.78 9.70 7.08 23.5 17.9 5.6
Growing. 10.16 1.61 8.55 5.81 0.86 4.95 10.7 1.7 9.0
Replenishing. 20.80 10.32 10.48 8.93 0.84 6.09 11.9 3.0 8.9
Total. 55.94 31.46 24.48 31.52 11.40 20.12 46.1 22.8 23.5
Run-off in inches on catchment area
Precipitation in inches on catchment area

FIG. 15.—Run-off diagram of Sudbury River.

Fig. 16 is a diagram of the revised gagings of Croton River from 1877 to 1899, inclusive

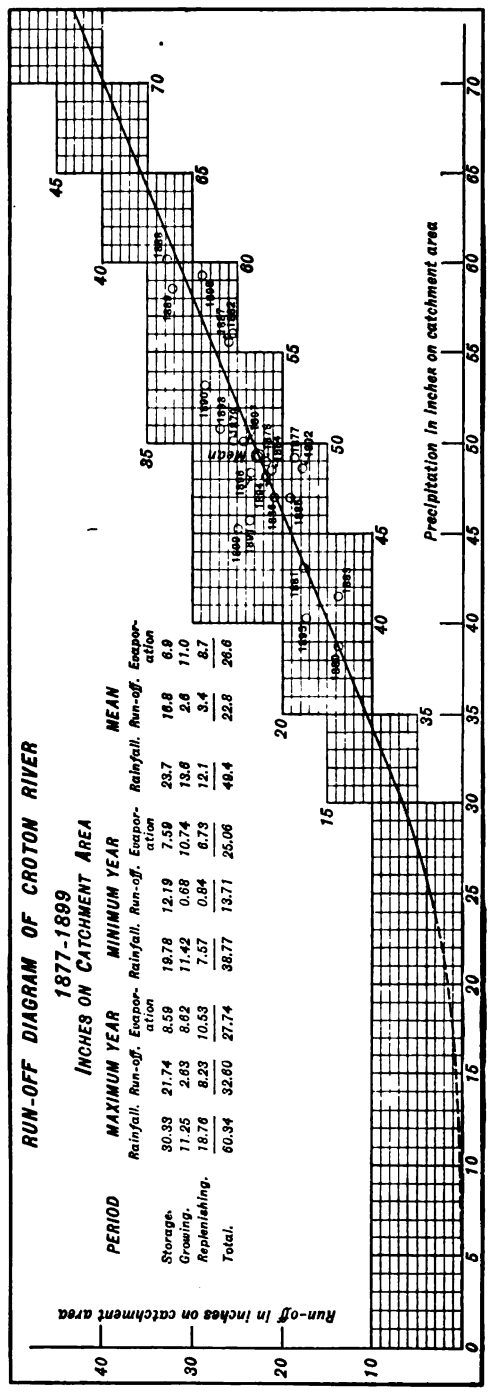

FIG. 16.—Run-off diagram of Croton River.

The maximum, minimum, and mean run-off may be obtained from the tabulations on each figure except for Passaic River.

It is evident that proceeding in the same way as for the foregoing diagrams, figs. 12–16, inclusive, diagrams may be prepared for the storage, growing, and replenishing periods, and a curve drawn from which the run-off for a given rainfall may be taken.

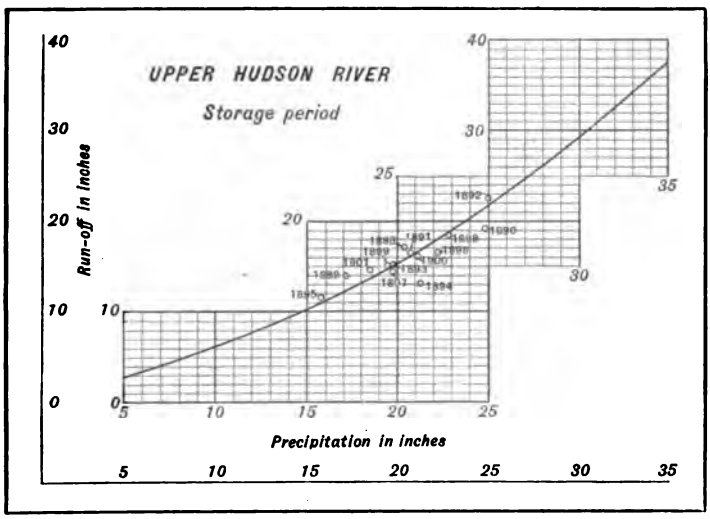

FIG. 17.—Diagram showing the relation between precipitation and run-off in the Upper Hudson River Basin during the storage period.

Fig. 17 is such a diagram for the storage period on the Upper Hudson River for the years 1888–1901, inclusive. This diagram shows that aside from the years 1890 and 1894 the run-offs of this catchment area were substantially accurate during the storage period. It is

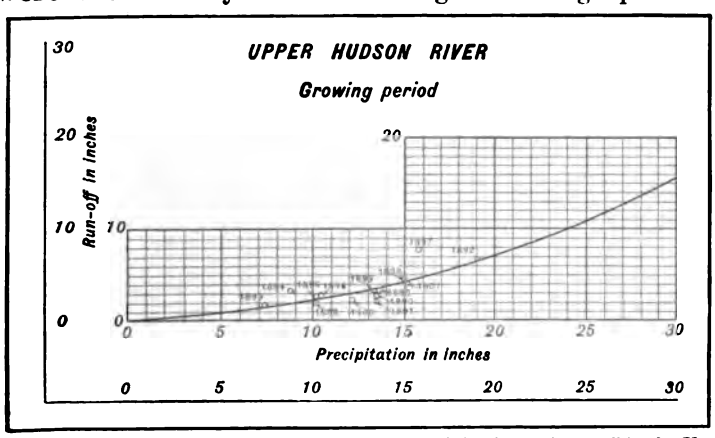

FIG. 18.—Diagram showing the relation between the precipitation and run-off in the Upper Hudson River Basin during the growing period.

probable that in these two years their accuracy may have been interfered with by ice, although just the cause is not definitely known—it may have been in the rainfall.

Fig. 18 is a similar diagram for the Upper Hudson River during the

growing period for the same years. This diagram shows that aside from 1897, the run-offs were substantially right during this period.

Fig. 19 is a similar diagram for the Upper Hudson River during the replenishing period for the same years. This diagram shows that in

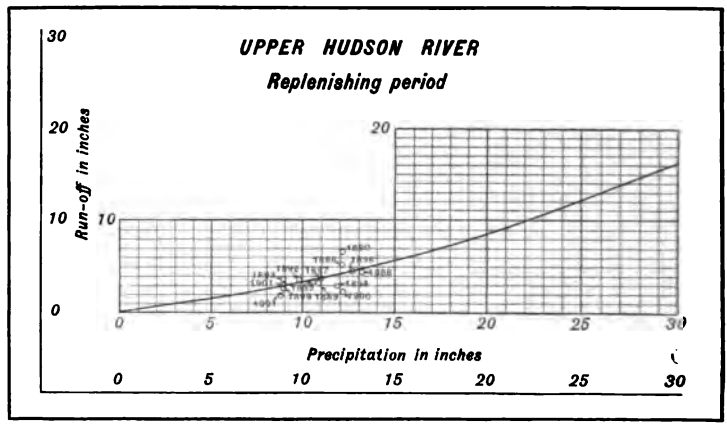

FIG. 19.—Diagram showing the precipitation and run-off in the Upper Hudson River Basin during the replenishing period.

1890 and 1900 there was a discrepancy, which, as in the previous cases, was presumably in the precipitation of that period.

Fig. 20 is a similar diagram for the storage period of Sudbury River. The observations in this case are so scattering that we may safely conclude that ice plays a very important part in the discord-

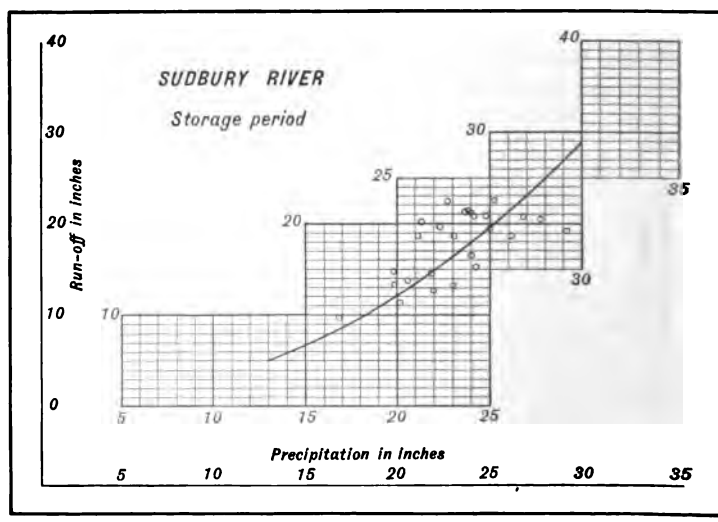

FIG. 20.—Diagram showing the relation between precipitation and run-off in the Sudbury River Basin during the storage period.

ancy of Sudbury River observations during the storage period. There is, however, during the earlier years, a lack of complete precipitation observations on the Sudbury catchment area, although it is not considered that this is a very important cause, for the reason that the

growing and replenishing periods on this stream show much better results than the storage period. The most probable assumption, therefore, seems to be the disturbing effect of ice in the storage period.

Fig. 21 is a similar diagram of Sudbury River for the growing period. With the exception of three years, the observations for this period are very reliable.

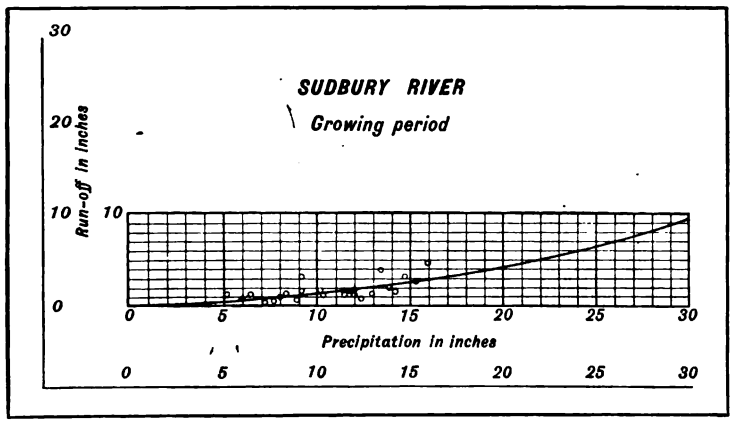

FIG. 21.—Diagram showing the relation between precipitation and run-off in the Sudbury River Basin during the growing period.

Fig. 22 is a similar diagram of Sudbury River for the replenishing period. In this case, the observations are all good except for one year.

Proceeding on similar lines, the writer prepared, several years ago,

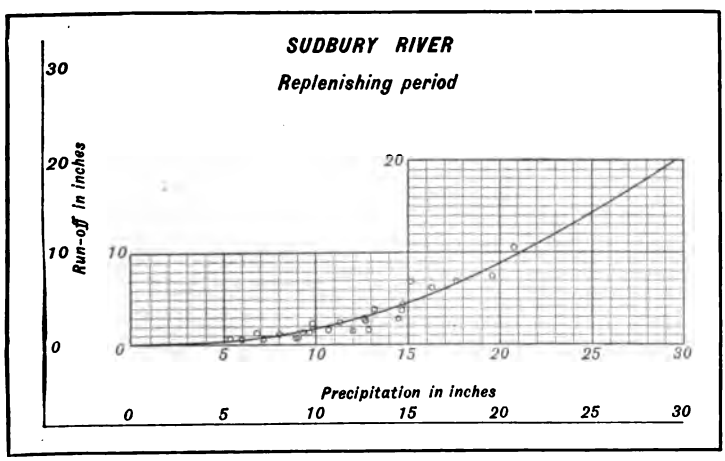

FIG. 22.—Diagram showing the relation between precipitation and run-off in the Sudbury River Basin during the replenishing period.

a series of curves, from which the monthly run-offs may be taken. But, unfortunately, owing to negative evaporation in the storage period, the individual months of that period were so discordant as to be very unsatisfactory. The writer, therefore, does not give any such

diagrams in this connection. His present view is that, for the reason stated, they can not be safely used.

Fig. 23 is a section of Mechanicville dam, over which the gagings of Hudson River have been made.

One or two general conclusions of some interest may be drawn from figs. 12–16, inclusive. For instance, taking the extreme low water as represented by the year 1895, on Muskingum River, at 4.9 inches for the whole year, with a rainfall of 29.8 inches, it is interesting to observe that in the preceding year of 1894, there was a total run-off of 8.7 inches, with a total rainfall of 30.5 inches. That is to say, the rainfall for the year 1894 was 0.7 inch greater than in 1895, but the run-off was 3.8 inches greater. This extreme difference may be ascribed to the difference in the height of ground water. In 1895, ground water stood much lower than in 1893, with the result of a lower run-off.

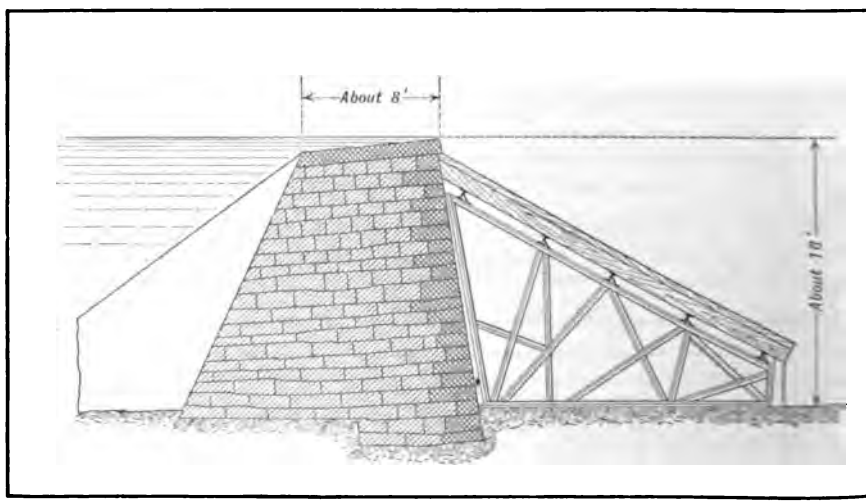

FIG. 23.—Section of Mechanicville dam.

On fig. 12, with a precipitation of 30 inches, the run-off is found to be 6 inches, while on fig. 13, with a precipitation of 30 inches, run-off ordinarily may be expected to be about 8 inches. This statement is made on the assumption that the curve is drawn in a mean position, or in such a way as to give average mean results, but it should not be overlooked that Muskingum River observations are too few to draw absolute conclusions. The diagram, fig. 13, shows that there is some lack of accuracy in at least one-half of them.

Fig. 12 shows that on Hudson River, if during any year the total rainfall should sink to 30 inches, the run-off may be expected to be somewhat less than 10 inches, though the modifying effect of full or low ground water may be taken into account in reaching such conclusion. Probably there would be, due to elevation of ground water, a variation of perhaps 2 inches.

On the diagram of Passaic River, fig. 14, 30 inches of precipitation indicates 14 inches of run-off. This is very high, and shows that further study of the Passaic is needed before one can safely accept the results as entirely reliable.

On the diagram of Sudbury River, fig. 15, a precipitation of 30 inches may be expected to produce a run-off of about 7 inches, showing that this stream is, as regards run-off characteristics, very closely allied to Genesee and Muskingum rivers.

On the diagram of Croton River, fig. 16, it is also seen that 30 inches precipitation may be expected to produce a little less than 7 inches of run-off, showing also that this stream has substantially the characteristics of Genesee River.

In all of the foregoing statements as to minimum run-off, it should be understood that the actual quantity appearing in the stream as run-off from a given precipitation will vary, depending on whether ground water is high or low at the beginning of the period considered. All such statements, therefore, are necessarily approximate—they may have a plus or minus variation from the diagram of one or two inches.

SUMMARY.

In order to assist the discussion, the following summary, which includes, it is believed, the more important points of the paper, is herewith submitted:

1. There is no general expression giving accurately the relation of rainfall to run-off. The run-off of a stream is influenced by so many complex elements that the data are lacking for final conclusions. Every stream is, in effect, a law unto itself. An empirical formula may, however, be made, which will give for some streams approximately the run-off for a series of years.

2. The cause of rainfall is not very well understood, although there is one principle upon which there is no disagreement—that in order to produce rain, the temperature of the air must be cooled below the dew point.

3. The errors in rainfall measurements are so large that one may safely state that nearly all measurements are merely approximations.

4. In view of the foregoing proposition, to carry rainfall measurements out to more than one decimal place is an unnecessary refinement.

5. As a general statement the minimum rainfall may be placed at from one-half to one-fourth of the maximum.

6. It is uncertain whether rainfall is in any degree increasing.

7. In England there is sometimes an increase of rainfall with increase of elevation,[a] but in the United States the areas are so large

[a] See remarks of H. Somerby Wallis on this point in Monthly Weather Review for April, 1902, p. 228.

that as soon as one goes away from the influence of the ocean very frequently this peculiarity does not appear. In a very large number of cases the reverse is true.

8. Contours can not be satisfactorily drawn on a rainfall map of the State of New York until we have a larger number of stations and longer periods of observation.

9. Rainfall and run-off records are conveniently divided into storage, growing, and replenishing periods, such division facilitating computations and bringing out the salient points. A large percentage of the total water supply runs off during the storage period.

10. Assuming that a rainfall record is accurate, it should cover about thirty-five years before it can be relied upon within 2 per cent. As to a run-off record, the number of long records are as yet too few to furnish satisfactory answers to questions concerning run-off.

11. The best unit of measurement is cubic feet per second, and the next best is inches on the catchment area.

12. The run-off of streams has been generally overestimated. The minimum flow may be as low as from 0.05 to 0.1 of a cubic foot per square mile per second. Streams issuing from sand plains may show from 0.5 to 0.6 of a cubic foot per square mile per second. Generally speaking, the range will not be outside of from 0.05 to 0.5 of a cubic foot per square mile per second.

13. As regards run-off, streams may be divided into classes, in the first of which will fall streams with a maximum rainfall from 50 to 60 inches and with a maximum run-off somewhat more than one-half the rainfall, etc. They may be also classified with regard to evaporation, as will be noted further on.

14. The run-off of streams can not be satisfactorily estimated from diagrams of monthly rainfall.

15. The run-off of a stream is materially influenced by the number of lakes within its catchment area.

16. Generally speaking, maximum-discharge formulas are unsatisfactory guides and are hardly worth the trouble their use entails. Exceptions to this may be taken in the use of Dickens and Ryves's formulas.

17. Safe deductions can not be made from an average run-off. What is wanted is a clear statement of the minimum, together with the longest period which it may be expected to occupy.

18. There is very serious danger in using percentages.

19. The influence of the May rainfall is such that when above the normal, stream flow is likely to be well maintained during the summer.

20. As regards delivery of streams, what is wanted in a stream is as large a ground flow as possible, with small evaporation.

21. When rainfall is below the mean for several months, ground water may be expected to become continuously lower, with the result that the flow of streams will be less.

22. The run-off of streams will vary with the velocity of wind, pressure, force of vapor, etc.

23. For individual streams an exponential formula is undoubtedly the best. By its use the given data may be more closely represented than in any other manner.

24. Annual run-off diagrams may be taken as a criterion as to the accuracy with which the observations have been made.

25. When a run-off record is given, without the rainfall, the rainfall may be computed by assuming the evaporation and making a series of approximations.

26. The run-off of streams with very great difference in size of catchment areas may be experimentally compared.

27. The extreme low-water period may extend over at least two years and occasionally over three years.

28. In order to clarify the whole matter of stream gagings, what is wanted in the future is a brief, explicit statement of just how the stream was measured, thus enabling hydrologists to judge of the accuracy of the method.

29. There is considerable variation in weir measurements, due to form of weir alone. The formula for a sharp-crested weir can not be applied to any other form without large variation.

30. The several diagrams, as well as the evaporation formula, show that there is no relation between evaporation and mean annual temperature.

31. The laws of evaporation are exhibited in the chapter on "Evaporation relations," by Professor Tate.

32. Evaporation is a persistently uniform element. The tendency is to remain at about the same figure from year to year.

33. In addition to the classification of streams with reference to rainfall, those with large evaporations may be placed in a class by themselves.

34. Streams with large evaporation are, so far as known, always deforested.

35. Negative evaporation exists on all the streams included in the tables. When negative evaporation exceeds more than two consecutive months there is, generally speaking, some doubt about the accuracy of the record.

36. The ground water must be taken into account in order to understand all the peculiarities of flow. A very important effect of forests is in increasing the ground-water flow.

37. It is uncertain whether difference in geology has much influence on run-off, although it appears that porous, sandy soils do considerably affect the result. There are, however, a number of cases which indicate that it may have important influence, although an examination of the evidence shows that the theory that forests materially influence

the run-off is more reasonable than that percolation through geologic formations exercises much influence.

38. So far as present information goes there is little or no relation between topography and the run-off of streams. Deforestation appears to exercise a much more important influence.

39. It is uncertain whether forests in any way influence the quantity of rainfall.

40. The extent of forestation seems to have considerable effect on the run-off of streams, catchments with dense forests showing larger run-off for the same rainfall than those which are deforested. As a tentative proposition it may be said that the removal of forests notably decreases stream flow.

41. The effect of forests is clearly shown on Hudson River.

42. Catchment areas from which municipal water supplies are drawn should be heavily forested. This is a broad proposition merely.

43. If the Croton catchment area had growing upon it a forest from one hundred to one hundred and fifty years old there would probably be, on an average, about 5 inches more annual run-off then there is under present conditions. Nevertheless it would not be a good investment for the city of New York to reforest this area, for the reason that the gain in water supply would not be commensurate with the expense.

The foregoing summary indicates a large number of factors which in some degree affect the run-off of streams. Moreover, only the main factors have been noted; there are many more of less importance.

There is a large amount of useful information on the general subject of the relation of forests to rainfall in Bulletin No. 7 of the Forestry Division of United States Department of Agriculture—Forest Influences—which, since that bulletin is readily obtained, has not been specially referred to here.

Finally, this paper is an attempt to establish a more rational theory of the relation between rainfall and run-off of streams than has thus far obtained.

TABLES.

TABLE NO. 1.—*Muskingum River, 1888–1895, inclusive.*

[Catchment area=5,828 square miles.]

Period.	1888.			1889.			1890.		
	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.
Storage	17.16	5.17	11.99	13.52	6.02	7.50	27.77	18.07	9.70
Growing	14.31	1.77	12.54	12.12	1.24	10.88	13.68	2.64	11.04
Replenishing	11.14	3.39	7.75	10.24	.96	9.28	15.52	6.13	9.39
Year	42.61	10.33	32.28	35.88	8.22	27.66	56.97	26.84	30.13

	1891.			1892.			1893.		
Storage	16.72	12.42	4.30	20.39	9.06	11.33	25.04	14.13	10.91
Growing	13.56	1.77	11.79	16.54	3.65	12.89	8.31	1.22	7.09
Replenishing	7.08	1.37	5.71	4.81	.67	4.14	9.01	.85	8.16
Year	37.36	15.56	21.80	41.74	13.38	28.36	42.36	16.20	26.16

	1894.			1895.		
Storage	16.93	7.63	9.30	13.04	4.04	9.00
Growing	4.56	.66	3.90	9.14	.49	8.65
Replenishing	9.02	.41	8.61	7.66	.37	7.29
Year	30.51	8.70	21.81	29.84	4.90	24.94

TABLE NO. 2.—*Genesee River, 1890–1898, inclusive.*

[Catchment area = 1,070 square miles.]

Period.	1890.			1891.			1892.		
	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.
Storage	[a]23.01	[b]12.96	[b]10.05	18.22	11.88	6.34	19.84	9.38	10.46
Growing	[a]10.52	2.51	8.01	12.78	1.06	11.72	15.30	4.90	10.40
Replenishing	[a]14.01	5.75	8.26	7.12	1.11	6.01	6.55	1.14	5.41
Year	[a]47.54	[b]21.22	[a]26.32	38.12	14.05	24.07	41.69	15.42	26.27

	1893.			1894.			1895.		
Storage	20.65	[b]11.10	[b]9.55	27.71	15.73	11.98	13.20	5.63	7.57
Growing	9.55	[b]1.00	[b]8.55	7.95	1.46	6.49	11.13	.36	10.77
Replenishing	9.10	1.25	7.85	12.13	2.19	9.94	6.67	.68	5.99
Year	39.30	[b]13.35	[b]25.95	47.79	19.38	28.41	31.00	6.67	24.33

	1896.			1897.			1898.		
Storage	17.84	9.25	8.59	15.68	7.31	8.37	18.66	10.40	8.26
Growing	10.28	.83	9.45	11.92	1.34	10.58	14.15	2.05	12.10
Replenishing	12.56	2.72	9.84	6.79	.73	6.06	9.69	2.68	7.01
Year	40.68	12.80	27.88	34.39	9.38	25.01	42.50	15.13	27.37

[a] For years 1890–1892 the run-off is that of Oatka Creek, a tributary of Genesee River, and the rainfall of Oatka Creek catchment area has been taken rather than that of entire upper Genesee area.

[b] Approximate.

TABLE No. 3.—*Croton River, 1868–1899, inclusive.*

[Catchment area=338.8 square miles.]

Period.	1868.			1869.			1870.		
	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.
Storage	23.24	17.25	5.99	21.89	15.75	6.14	28.42	19.01	9.41
Growing	13.64	5.75	7.89	7.77	2.01	5.76	10.59	1.56	9.03
Replenishing	14.85	11.06	3.79	15.09	4.39	10.70	10.09	.96	9.13
Year	51.73	34.06	17.67	44.75	22.15	22.60	49.10	21.53	27.57
	1871.			1872.			1873.		
Storage	19.83	9.72	10.11	14.57	10.31	4.26	22.19	18.52	3.67
Growing	16.04	2.61	13.43	14.33	3.01	11.32	8.65	1.54	7.11
Replenishing	11.95	5.65	6.30	10.75	4.38	6.37	12.58	3.20	9.38
Year	47.82	17.98	29.84	39.65	17.70	21.95	43.42	23.26	20.16
	1874.			1875.			1876.		
Storage	23.74	22.86	0.88	17.10	14.81	2.29	22.64	19.89	2.75
Growing	12.30	2.77	9.53	16.45	5.86	10.59	7.14	1.07	6.07
Replenishing	8.68	1.60	7.08	10.33	3.41	6.92	10.11	1.35	8.76
Year	44.72	27.23	17.49	43.88	24.08	19.80	39.89	22.31	17.58
	1877.			1878.			1879.		
Storage	17.49	12.36	5.13	20.99	14.19	6.80	25.17	20.81	4.36
Growing	13.17	.96	12.21	11.29	2.57	8.72	18.09	2.63	15.46
Replenishing	18.46	5.49	12.97	16.72	5.01	11.71	6.96	1.88	5.08
Year	49.12	18.81	30.31	49.00	21.77	27.22	50.22	25.32	24.90
	1880.			1881.			1882.		
Storage	19.78	12.19	7.59	24.53	14.79	9.74	27.91	16.85	11.06
Growing	11.42	.68	10.74	9.61	1.95	7.66	9.03	2.06	6.97
Replenishing	7.57	.84	6.73	8.96	.97	7.99	19.10	6.21	12.89
Year	38.77	13.71	25.06	43.10	17.71	25.39	56.04	25.12	30.92
	1883.			1884.			1885.		
Storage	19.03	11.37	7.66	24.81	16.85	7.96	21.86	15.36	6.50
Growing	12.10	1.09	11.01	15.72	2.34	13.38	12.89	.88	12.01
Replenishing	10.41	1.28	9.13	8.01	1.87	6.14	12.23	2.92	9.31
Year	41.54	13.74	27.80	48.54	21.06	27.48	46.98	19.16	27.82
	1886.			1887.			1888.		
Storage	25.45	18.16	7.29	23.05	16.44	6.61	30.33	21.74	8.59
Growing	11.68	1.53	10.15	24.75	6.71	18.04	11.25	2.63	8.62
Replenishing	9.82	1.23	8.59	7.78	2.60	5.18	18.76	8.23	10.53
Year	46.95	20.92	26.03	55.58	25.75	29.83	60.34	32.60	27.74

TABLE NO. 3.—*Croton River, 1868–1899, inclusive*—Continued.

Period.	1889.			1890.			1891.		
	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.
Storage	22.40	16.86	5.54	25.31	19.10	6.21	26.66	21.22	5.44
Growing	17.37	6.49	10.88	13.31	2.51	10.80	11.26	1.14	10.12
Replenishing	18.83	8.70	10.13	14.60	7.02	7.58	7.78	1.11	6.67
Year	58.60	32.05	26.55	53.22	28.63	24.59	45.70	23.47	22.23

	1892.			1893.			1894.		
Storage	22.93	12.87	10.06	27.34	21.41	5.93	23.24	15.65	7.59
Growing	15.37	2.60	12.77	12.39	1.84	10.55	7.95	1.82	6.13
Replenishing	10.30	2.31	7.99	11.08	3.51	7.57	17.05	4.41	12.64
Year	48.60	17.78	30.82	50.81	26.76	24.05	48.24	21.88	26.36

	1895.			1896.			1897.		
Storage	19.55	14.78	4.77	24.84	18.01	6.83	20.55	14.64	5.91
Growing	11.19	1.05	10.14	12.25	2.03	10.22	20.79	6.93	13.86
Replenishing	9.54	1.27	8.27	11.27	3.13	8.14	8.76	2.73	6.03
Year	40.28	17.10	23.18	48.36	23.17	25.19	50.10	24.30	25.80

				1898.			1899.		
Storage				28.81	20.08	8.73	22.66	21.38	1.28
Growing				17.17	4.83	12.34	12.19	1.57	10.62
Replenishing				13.36	3.99	9.37	10.37	1.96	8.41
Year				59.34	28.90	30.44	45.22	24.91	20.31

				Mean 1868–1876, inclusive.			Mean 1877–1899, inclusive.		
Storage				21.51	16.46	5.05	23.68	16.83	6.85
Growing				11.88	2.91	8.97	13.58	2.57	11.01
Replenishing				11.61	4.00	7.61	12.08	3.42	8.66
Year				45.00	23.37	21.63	49.33	22.81	26.52

TABLE NO. 4.—*Lake Cochituate, 1863–1900, inclusive.*

[Catchment area=18.9 square miles, not including catchment of Dudley Pond.]

Period.	1863.			1864.			1865.		
	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation
Storage	29.49	16.31	13.18	24.70	14.44	10.26	29.63	17.28	12.35
Growing	21.71	5.15	16.56	5.20	1.58	3.62	7.37	1.27	6.10
Replenishing	16.49	5.25	11.24	13.47	3.17	10.30	13.43	2.15	11.28
Year	67.69	26.71	40.98	43.37	19.19	24.18	50.43	20.70	29.73
	1866.			1867.			1868.		
Storage	22.87	9.38	13.49	27.02	16.47	10.55	23.02	16.95	6.07
Growing	22.13	2.94	19.19	20.67	3.34	17.33	12.49	3.22	9.27
Replenishing	16.31	3.26	13.05	10.98	2.43	8.55	15.65	4.76	10.89
Year	61.31	15.58	45.73	58.67	22.44	36.43	51.16	24.93	26.23
	1869.			1870.			1871.		
Storage	28.91	12.83	16.08	36.50	23.72	12.78	19.77	10.19	9.58
Growing	8.65	2.39	6.26	9.18	1.91	7.27	11.72	2.15	9.57
Replenishing	21.25	4.77	16.48	13.00	2.85	10.15	13.85	2.38	11.47
Year	58.81	19.99	38.82	58.68	28.48	30.20	45.34	14.72	30.62
	1872.			1873.			1874.		
Storage	14.51	8.88	5.63	20.00	18.51	1.49	20.76	16.23	4.53
Growing	19.58	2.95	16.63	11.63	2.47	9.16	12.78	3.83	8.95
Replenishing	14.20	5.39	8.81	13.27	4.68	8.59	4.64	1.63	3.01
Year	48.29	17.22	31.07	44.90	25.66	19.24	38.18	21.69	16.49
	1875.			1876.			1877.		
Storage	17.80	10.76	7.04	20.45	14.91	5.54	21.61	15.65	5.96
Growing	15.34	2.35	12.99	13.28	1.64	11.64	8.76	2.24	6.52
Replenishing	13.11	3.75	9.36	12.57	3.22	9.35	15.54	4.31	11.23
Year	46.25	16.86	29.39	46.30	19.77	26.53	45.91	22.20	23.71
	1878.			1879.			1880.		
Storage	23.38	19.08	4.30	19.96	16.83	3.13	18.47	8.55	9.92
Growing	13.74	2.07	11.67	13.95	2.05	11.90	12.06	.62	11.44
Replenishing	12.36	3.09	9.27	5.62	1.93	3.69	6.34	1.56	4.78
Year	49.48	24.24	25.24	39.53	20.81	18.72	36.87	10.73	26.14
	1881.			1882.			1883.		
Storage	22.23	12.74	9.49	23.10	12.39	10.71	16.62	8.31	8.31
Growing	8.74	1.56	7.18	6.50	.75	5.75	5.08	.16	4.92
Replenishing	8.85	1.25	7.60	12.35	2.39	9.96	8.53	1.62	6.91
Year	39.82	15.55	24.27	41.95	15.53	26.42	30.23	10.09	20.14

TABLE No. 4.—*Lake Cochituate, 1863–1900, inclusive*—Continued.

Period.	1884.			1885.			1886.		
	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.
Storage	24.79	15.70	9.09	22.80	11.90	10.90	24.14	18.97	5.17
Growing	12.79	1.54	11.25	11.70	.76	10.94	8.26	.57	7.69
Replenishing	5.82	1.09	4.73	12.15	3.09	9.06	11.12	1.92	9.20
Year	43.40	18.33	25.07	46.65	15.75	30.90	43.52	21.46	22.06
	1887.			1888.			1889.		
Storage	26.97	19.91	7.06	24.22	15.44	8.78	21.79	17.26	4.53
Growing	10.05	2.87	7.18	10.06	1.94	8.12	16.84	6.24	10.60
Replenishing	6.53	1.83	4.70	20.70	9.09	11.70	14.56	6.65	7.91
Year	43.55	24.61	18.94	55.07	26.47	28.60	53.19	30.15	23.04
	1890.			1891.			1892.		
Storage	23.42	17.17	6.25	27.73	28.21	−0.48	21.11	12.47	8.64
Growing	7.43	2.20	5.23	11.68	1.99	9.69	10.49	1.38	9.11
Replenishing	17.82	6.29	11.53	9.10	2.38	6.72	9.43	2.26	7.17
Year	48.67	25.66	23.01	48.51	32.58	15.93	41.03	16.11	24.92
	1893.			1894.			1895.		
Storage	22.84	12.40	10.44	21.00	10.25	10.75	20.18	11.29	8.89
Growing	11.01	1.90	9.11	7.79	1.24	6.55	11.79	1.45	10.34
Replenishing	7.58	2.51	5.07	10.94	2.04	8.90	18.66	6.17	12.49
Year	41.43	16.81	24.62	39.73	13.53	26.20	50.63	18.91	31.72
	1896.			1897.			1898.		
Storage	20.91	15.96	4.95	19.87	11.05	8.82	26.61	16.15	10.46
Growing	7.69	1.55	6.14	12.34	2.57	9.77	12.71	2.45	10.26
Replenishing	14.74	3.70	11.04	9.92	2.58	7.34	16.76	4.26	12.50
Year	43.34	21.21	22.13	42.13	16.20	25.93	56.08	22.86	33.22
				1899.			1900.		
Storage				22.31	18.38	3.93	28.80	14.09	14.21
Growing				8.16	.23	7.93	9.25	1.49	7.76
Replenishing				10.01	1.63	8.38	13.01	2.72	10.29
Year				40.48	20.24	20.24	50.56	18.30	32.26
				Mean for 5 years, 1896–1900, inclusive.			Mean for 38 years, 1863–1900, inclusive.		
Storage				23.60	15.13	8.47	23.15	14.92	8.23
Growing				10.03	1.66	8.37	11.59	2.08	9.51
Replenishing				12.89	2.98	9.91	12.38	3.32	9.06
Year				46.52	19.77	26.75	47.13	20.32	26.81

TABLE No. 5.—*Sudbury River, 1875–1900, inclusive.*

[Catchment area, 1875–1878, inclusive=77.76 square miles; 1879–80=78.24 square miles; 1881–1899=75.2 square miles.]

Period	1875.			1876.			1877.		
	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.
Storage	19.78	14.69	5.09	21.37	20.10	1.27	23.07	18.71	4.36
Growing	15.34	2.78	12.56	12.89	1.43	11.46	9.06	1.61	7.45
Replenishing	13.11	3.76	9.35	12.62	2.61	10.01	14.64	3.68	10.96
Year	48.23	21.23	27.00	46.88	24.14	22.74	46.77	24.00	22.77
	1878.			1879.			1880.		
Storage	23.91	21.05	2.86	23.84	21.19	2.65	20.15	11.19	8.96
Growing	13.79	1.95	11.84	14.23	1.70	12.53	12.42	.83	11.59
Replenishing	14.73	4.12	10.61	5.37	.72	4.65	7.13	.67	6.46
Year	52.43	27.12	25.31	43.44	23.61	19.83	39.70	12.69	27.01
	1881.			1882.			1883.		
Storage	24.27	15.07	9.20	23.99	16.33	7.66	16.78	9.70	7.08
Growing	9.10	3.07	6.03	5.10	1.17	3.93	5.81	.86	4.95
Replenishing	9.66	1.35	8.31	11.96	1.42	10.54	8.93	.84	8.09
Year	43.03	19.49	23.54	41.05	18.92	22.13	31.52	11.40	20.12
	1884.			1885.			1886.		
Storage	27.78	20.38	7.40	21.90	14.36	7.54	24.19	20.75	3.44
Growing	11.76	1.58	10.18	11.47	1.27	10.20	8.83	.72	8.11
Replenishing	5.98	.53	5.45	12.61	2.84	9.77	10.78	1.62	9.16
Year	45.52	22.49	23.03	45.98	18.47	27.51	43.80	23.09	20.71
	1887.			1888.			1889.		
Storage	25.28	22.43	2.85	24.98	19.53	5.45	21.14	18.71	2.43
Growing	11.69	1.30	10.39	10.16	1.61	8.55	15.91	4.81	11.10
Replenishing	6.93	1.17	5.66	20.80	10.32	10.48	15.15	6.97	8.18
Year	43.80	24.90	18.90	55.94	31.46	24.48	52.20	30.49	21.71
	1890.			1891.			1892.		
Storage	24.77	20.87	3.90	29.96	25.90	4.06	23.15	13.12	10.03
Growing	8.36	1.41	6.95	11.89	1.27	10.62	11.43	1.62	9.81
Replenishing	17.71	6.94	10.77	9.30	1.25	8.05	9.81	1.82	7.99
Year	50.84	29.22	21.62	51.15	28.42	22.73	44.39	16.56	27.83

TABLE NO. 5.—*Sudbury River, 1875–1900, inclusive*—Continued.

Period.	1893.			1894.			1895.		
	Rainfall.	Runoff.	Evaporation.	Rainfall.	Runoff.	Evaporation.	Rainfall.	Runoff.	Evaporation.
Storage	28.13	18.72	7.41	21.94	12.57	9.37	20.52	18.77	6.75
Growing	10.36	1.26	9.10	6.44	1.38	5.06	11.96	1.12	10.84
Replenishing	7.99	1.13	6.86	11.41	2.37	9.04	19.61	7.41	12.20
Year	44.48	21.11	23.37	39.79	16.32	23.47	52.09	22.30	29.79

	1896.			1897.			1898.		
Storage	22.30	19.64	2.66	19.88	13.23	6.65	26.81	20.65	6.16
Growing	8.13	.96	7.17	13.41	3.88	9.53	14.74	3.29	11.45
Replenishing	14.50	2.87	11.63	9.81	2.06	7.75	16.26	6.14	10.12
Year	44.93	23.47	21.46	43.10	19.17	23.93	57.81	30.08	27.73

	1899.			1900.		
Storage	22.73	22.28	0.45	29.13	19.12	10.01
Growing	7.16	.09	7.07	7.67	.46	7.21
Replenishing	8.82	.90	7.92	12.89	1.58	11.31
Year	38.71	23.27	15.44	49.69	21.16	28.53

	Mean for 5 years, 1896–1900, inclusive.			Mean for whole period, 1875–1900, inclusive.		
Storage	24.17	18.98	5.19	23.45	17.85	5.60
Growing	10.22	1.74	8.48	10.74	1.67	9.06
Replenishing	12.46	2.71	9.75	11.86	2.96	8.90
Year	46.85	23.43	23.42	46.05	22.48	23.56

TABLE No. 6.—*Mystic Lake, 1878–1895, inclusive.*

[Catchment area=26.9 square miles.]

Period.	1878.			1879.			1880.		
	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.
Storage	25.22	18.43	6.79	19.42	16.40	3.02	17.28	9.34	7.94
Growing	13.65	2.37	11.28	11.85	2.21	9.64	12.36	1.72	10.64
Replenishing	13.83	3.02	10.81	5.13	1.27	3.86	6.02	1.25	4.77
Year	52.70	23.82	28.88	36.40	19.88	16.52	35.66	12.31	23.35
	1881.			1882.			1883.		
Storage	23.16	14.02	9.14	22.69	12.47	10.22	16.24	7.41	8.83
Growing	10.11	3.27	6.84	5.49	1.38	4.11	5.29	1.04	4.25
Replenishing	7.85	1.10	6.75	12.03	1.50	10.53	8.93	.99	7.94
Year	41.12	18.39	22.73	40.21	15.35	24.86	30.46	9.44	21.02
	1884.			1885.			1886.		
Storage	24.21	16.57	7.64	21.35	11.03	10.32	24.47	20.82	3.65
Growing	13.21	2.03	11.18	12.35	1.87	10.48	8.49	1.21	7.28
Replenishing	5.40	.85	4.55	13.25	3.43	9.82	9.87	1.58	8.29
Year	42.82	19.45	23.37	46.95	16.33	30.62	42.83	23.61	19.22
	1887.			1888.			1889.		
Storage	25.83	17.44	8.39	24.03	16.09	7.94	23.17	17.47	5.70
Growing	14.24	3.49	10.75	10.66	1.77	8.89	15.69	5.27	10.42
Replenishing	7.59	1.76	5.83	20.37	9.09	11.28	13.94	4.76	9.18
Year	47.66	22.69	24.97	55.06	26.95	28.11	52.80	27.50	25.30
	1890.			1891.			1892.		
Storage	24.35	18.66	5.69	27.67	26.79	0.88	21.35	11.58	9.77
Growing	9.28	2.81	6.47	11.49	1.87	9.62	11.55	2.32	9.23
Replenishing	13.92	5.14	8.78	9.50	1.56	7.94	8.47	2.08	6.39
Year	47.55	26.61	20.94	48.66	30.22	18.44	41.37	15.98	25.39
	1893.			1894.			1895.		
Storage	23.09	15.42	7.67	21.34	11.14	10.20	18.50	10.34	8.16
Growing	9.55	2.20	7.35	6.69	1.78	4.91	13.41	1.82	11.59
Replenishing	8.36	1.67	6.69	11.59	1.85	9.74	18.50	4.09	14.41
Year	41.00	19.29	27.71	39.62	14.77	24.85	50.41	16.25	34.16

TABLE NO. 7.—*Neshaminy Creek, 1884–1899, inclusive.*

[Catchment area=139.3 square miles.]

Period.	1884.			1885.			1886.		
	Rainfall.	Runoff.	Evaporation.	Rainfall.	Runoff.	Evaporation.	Rainfall.	Runoff.	Evaporation.
Storage	25.77	25.61	0.16	20.13	17.85	2.28	26.61	21.45	5.16
Growing	13.71	1.85	11.86	10.25	1.08	9.17	12.67	1.87	10.80
Replenishing	7.05	.45	6.60	11.22	1.73	9.49	7.60	.66	6.94
Year	46.53	27.91	18.62	41.60	20.66	20.94	46.88	23.98	22.90

	1887.			1888.			1889.		
Storage	21.88	15.92	5.96	26.48	21.17	5.31	22.32	13.44	8.88
Growing	19.26	4.44	14.82	11.83	1.01	10.82	22.42	10.00	12.42
Replenishing	7.59	1.03	6.56	14.18	6.02	8.16	22.18	12.37	9.81
Year	48.73	21.39	27.34	52.49	28.20	24.29	66.92	35.81	31.11

	1890.			1891.			1892.		
Storage	22.06	14.85	7.21	23.48	17.74	5.74	22.55	15.01	7.54
Growing	14.28	2.15	12.13	15.90	2.53	13.37	11.58	1.31	10.27
Replenishing	10.23	3.33	6.90	8.08	2.38	5.70	10.13	1.94	8.19
Year	46.57	20.33	26.24	47.46	22.65	24.81	44.26	18.26	26.00

	1893.			1894.			1895.		
Storage	22.16	18.52	3.64	26.68	18.16	8.52	20.97	15.84	5.13
Growing	12.21	1.70	10.51	8.95	1.82	7.13	11.41	2.07	9.34
Replenishing	11.07	3.74	7.33	16.45	6.12	10.33	6.21	.24	5.97
Year	45.44	23.96	21.48	52.08	26.10	25.98	38.59	18.15	20.44

				1896.			1897.		
Storage				20.52	11.54	8.98	19.28	10.60	8.68
Growing				10.80	1.65	9.15	17.70	6.50	11.20
Replenishing				12.65	2.41	9.24	9.06	2.11	6.95
Year				43.97	16.60	27.37	46.04	19.21	26.83

				1898.			1899.		
Storage				25.68	16.87	8.81	23.09	20.50	2.59
Growing				12.34	1.69	10.65	9.41	1.76	7.65
Replenishing				12.80	3.33	9.47	10.91	1.96	8.95
Year				50.82	21.89	28.93	43.41	24.22	19.19

TABLE NO. 8.—*Perkiomen Creek, 1884–1899, inclusive.*

[Catchment area=152 square miles.]

Period.	1884.			1885.			1886.		
	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.
Storage	25.25	25.19	0.06	20.47	15.29	5.18	26.03	19.74	6.29
Growing	15.53	4.07	11.46	9.83	1.68	8.15	11.76	3.35	8.41
Replenishing	7.54	1.59	5.95	9.49	2.38	7.11	9.00	2.02	6.98
Year	48.32	30.85	17.47	39.79	19.35	20.44	46.79	25.11	21.68
	1887.			1888.			1889.		
Storage	21.63	14.66	6.97	27.48	19.67	7.81	22.99	14.28	8.71
Growing	17.26	4.26	13.00	12.42	2.17	10.25	23.38	10.02	13.36
Replenishing	6.70	1.45	5.25	14.18	7.40	6.78	20.45	11.81	8.64
Year	45.59	20.37	25.22	54.08	29.24	24.84	66.82	36.11	30.71
	1890.			1891.			1892.		
Storage	24.68	18.15	6.53	22.89	17.35	5.54	23.64	15.89	7.75
Growing	14.35	3.11	11.24	18.32	3.25	15.07	11.06	2.38	8.68
Replenishing	10.31	4.52	5.79	8.15	2.69	5.46	9.33	2.66	6.67
Year	49.34	25.78	23.56	49.36	23.29	26.07	44.03	20.93	23.10
	1893.			1894.			1895.		
Storage	22.16	17.21	4.95	24.37	15.77	8.60	23.22	15.51	7.71
Growing	12.20	1.82	10.38	8.77	2.05	6.72	10.88	1.32	9.56
Replenishing	10.18	3.33	6.85	15.40	5.18	10.22	6.25	.75	5.50
Year	44.54	22.36	22.18	48.54	23.00	25.54	40.35	17.58	22.77
				1896.			1897.		
Storage				19.99	10.26	9.73	20.00	12.37	7.63
Growing				15.05	2.83	12.22	13.69	3.08	10.61
Replenishing				14.62	4.19	10.43	10.07	2.26	7.81
Year				49.66	17.28	32.38	43.76	17.71	26.05
				1898.			1899.		
Storage				24.24	15.74	8.50	22.79	20.49	2.30
Growing				9.98	1.39	8.59	14.12	2.46	11.66
Replenishing				13.85	3.90	9.95	11.36	4.01	7.35
Year				48.07	21.03	27.04	48.27	26.96	21.31

TABLE NO. 9.—*Tohickon Creek, 1884–1898, inclusive.*

[Catchment area=102.2 square miles.]

Period.	1884.			1885.			1886.		
	Rainfall.	Runoff.	Evaporation.	Rainfall.	Runoff.	Evaporation.	Rainfall.	Runoff.	Evaporation.
Storage	26.06	27.27	−1.21	21.86	19.45	2.41	28.54	27.79	0.75
Growing	17.52	6.53	10.99	11.31	1.54	9.77	11.10	2.27	8.83
Replenishing	7.97	1.35	6.62	10	2.94	7.06	9.05	2.04	7.01
Year	51.55	35.15	16.40	43.17	23.93	19.24	48.69	32.10	16.59
	1887.			1888.			1889.		
Storage	21.60	18.44	3.16	28.52	27.37	1.15	25.13	17.82	7.31
Growing	19.19	4.80	14.39	12.96	1.99	10.97	23.90	12.45	11.45
Replenishing	6.71	.91	5.80	16.04	10.14	5.90	21.34	13.70	7.64
Year	47.50	24.15	23.35	57.52	39.50	18.02	70.37	43.97	26.40
	1890.			1891.			1892.		
Storage	25.09	19.01	6.08	23.07	20.23	2.84	23.43	19.76	3.67
Growing	15.49	2.54	12.95	19.77	4.99	14.78	11.22	1.52	9.70
Replenishing	10.20	5.45	4.75	7.16	2.03	5.13	10.65	3.47	7.18
Year	50.78	27	23.78	50	27.25	22.75	45.30	24.75	20.55
	1893.			1894.			1895.		
Storage	22.82	22.05	0.77	27.04	21.65	5.39	21.35	19.91	1.44
Growing	14.82	2.10	12.72	6.95	.84	6.11	12.45	1.46	10.99
Replenishing	11.31	4.06	7.25	17.63	8.11	9.52	6.63	.28	6.35
Year	48.95	28.21	20.74	51.62	30.60	21.02	40.43	21.65	18.78
	1896.			1897.			1898.		
Storage	21.69	12.30	9.39	20.82	13.93	6.89	26.40	21.20	5.20
Growing	13.76	2.91	10.85	17.32	5.12	12.20	10.87	1	9.87
Replenishing	12.58	4.52	8.06	8.78	1.98	6.80	13.80	5.19	8.61
Year	48.03	19.73	28.30	46.92	21.03	25.89	51.07	27.39	23.68

TABLE NO. 10.—*Hudson River, 1888–1901, inclusive.*

[Catchment area=4,500 square miles.]

Period.	1888.			1889.			1890.		
	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.
Storage	20.40	17.06	3.34	17.10	14.04	3.06	24.75	19.28	5.47
Growing	10.25	2.05	8.20	15.05	4.28	10.79	13.50	2.85	10.65
Replenishing	13.27	4.53	8.74	10.81	3.41	7.40	12.10	6.81	5.29
Year	43.92	[a]28.64	20.28	[a]42.96	21.71	21.25	[a]50.35	28.94	21.41

	1891.			1892.			1893.		
Storage	20.69	16.59	4.10	24.95	22.50	2.45	19.83	15.20	4.63
Growing	13.49	2.07	11.42	19.12	6.87	12.25	13.37	3.12	10.25
Replenishing	8.78	1.90	6.88	9.80	3.71	6.09	8.98	3.59	5.39
Year	42.96	20.56	22.40	53.87	33.08	20.79	42.18	21.91	20.27

	1894.			1895.			1896.		
Storage	21.37	13.18	8.19	15.79	11.68	4.11	22.17	16.52	5.65
Growing	8.73	3.20	5.53	10.37	2.36	8.01	10.25	2.53	7.72
Replenishing	11.87	2.99	8.88	10.51	3.42	7.09	12.79	4.58	8.21
Year	41.97	19.37	22.60	36.67	17.46	19.21	45.21	23.62	21.58

	1897.			1898.			1899.		
Storage	19.77	14.60	5.17	22.80	18.61	4.19	19.48	15.15	4.33
Growing	15.80	7.79	8.01	13.52	8.24	10.28	7.40	1.63	5.77
Replenishing	10.94	3.80	7.14	12.19	5.27	6.92	8.91	2.76	6.15
Year	46.51	26.19	20.32	48.51	27.12	21.39	35.79	19.54	16.25

				1900.			1901.		
Storage				21.13	16.12	5.01	18.47	14.84	3.63
Growing				12.11	2.30	9.81	15.09	4.02	11.07
Replenishing				12.17	2.25	9.92	9.02	3	6.02
Year				45.41	20.67	24.74	42.58	21.86	20.72

[a] Approximate.

TABLE No. 11.—*Pequannock River, 1891–1899, inclusive.*

[Catchment area=63.7 square miles.]

Period.	1891.			1892.			1893.		
	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.
Storage	26.78	17.49	9.29	19.54	18.11	1.43	24.70	23.62	1.08
Growing	12.52	2.21	10.31	12.83	3.46	9.37	13.02	2.53	10.49
Replenishing	7.23	2.97	4.26	9.17	2.23	6.94	10.72	4.44	6.28
Year	46.53	22.67	23.86	41.54	23.80	17.74	48.44	30.59	17.85
	1894.			1895.			1896.		
Storage	20.29	18.59	1.70	19.69	18.08	1.61	25.62	19.29	6.33
Growing	5.81	2.20	3.61	10.07	1.66	8.41	13.51	3.47	10.04
Replenishing	16.33	8.33	8	8.16	1.37	6.79	14.52	7.18	7.34
Year	42.43	29.12	13.31	37.92	21.11	16.81	53.65	29.94	23.71
	1897.			1898.			1899.		
Storage	21.05	17.57	3.48	27.29	22.74	4.55	22.29	21.95	0.34
Growing	21.31	8.10	13.21	12.24	2.48	9.76	12.57	1.88	10.69
Replenishing	9.50	2.83	6.67	13.48	3.54	9.94	10.96	2.74	8.22
Year	51.86	28.50	23.36	53.01	28.76	24.25	45.82	26.57	19.25

TABLE No. 12.—*Connecticut River, 1872–1885, inclusive.*

[Catchment area = 10,234 square miles.]

Period.	1872.			1873.[a]			1874.[a]		
	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.	Rainfall.	Run-off.	Evaporation.
Storage	14.92	13.30	1.62	18.16	21.80	− 3.64	23.08	23.04	0.04
Growing	18.96	6.29	12.67	10.11	2.71	7.40	14.37	6.62	7.75
Replenishing	12.42	6.64	5.78	15.04	5.22	9.82	7.76	2.15	5.61
Year	46.30	26.23	20.07	43.31	29.73	13.58	45.21	31.81	13.4

Period.	1875.			1876.[a]			1877.		
Storage	17.51	15.47	2.04	22.50	24.74	− 2.24	18.09	12.68	5.41
Growing	14.55	3.80	10.75	12.51	3.35	9.16	14.00	2.91	11.09
Replenishing	11.38	3.60	7.76	10.57	2.28	8.29	13.08	5.27	7.81
Year	43.42	22.87	20.55	45.58	30.37	15.21	45.17	20.86	24.31

Period.	1878.			1879.			1880.		
Storage	21.88	18.02	3.86	23.19	21.49	1.70	18.29	14.78	3.51
Growing	13.59	3.45	10.14	16.07	2.92	13.15	11.82	2.45	9.37
Replenishing	10.56	3.06	7.50	9.48	2.93	6.55	11.58	2.62	8.96
Year	46.03	24.53	21.50	48.74	27.34	21.40	41.69	19.85	21.84

Period.	1881.			1882.			1883.		
Storage	20.83	16.02	4.81	[b]20.50	12.14	8.36	[b]12.85	8.73	4.12
Growing	11.30	2.93	8.37	[b]11.45	3.35	8.10	[b]13.50	2.51	10.99
Replenishing	11.38	3.39	7.99	[b]6.50	2.17	4.33	[b]6.20	1.37	4.83
Year	43.51	22.34	21.17	38.45	17.66	20.79	32.55	12.61	19.94

Period.	1884.			1885.		
Storage	21.42	20.20	1.22	18.58	13.63	4.95
Growing	12.14	2.79	9.35	14.82	3.20	11.62
Replenishing	8.51	2.61	5.90	11.76	5.61	6.15
Year	42.07	25.60	16.47	45.16	22.44	22.72

[a] Not included in mean.

[b] Rainfall computed, approximate.

TABLE NO. 13.—*Mean or average rainfall, run-off, and evaporation for storage, growing, and replenishing periods for 12 streams of the United States.*

Period.	Muskingum River, from 1888 to 1895, eight years. Catchment area, 5,828 square miles.			Genesee River, from 1890 to 1898, nine years. Catchment area, 1,070 square miles.			Croton River, from 1877 to 1899, twenty-three years. Catchment area, 338.8 square miles.		
	Rain.	Run-off.	Evaporation.	Rain.	Run-off.	Evaporation.	Rain.	Run-off.	Evaporation.
Storage	18.8	9.6	9.2	19.4	10.5	8.9	23.7	16.8	6.9
Growing	11.6	1.7	9.9	11.5	1.7	9.8	13.6	2.6	11.0
Replenishing	9.3	1.8	7.5	9.4	2.0	7.4	12.1	3.4	8.7
Year	39.7	13.1	26.6	40.3	14.2	26.1	49.4	22.8	26.6

Period.	Lake Cochituate, from 1863 to 1900, thirty-eight years. Catchment area, 18.9 square miles.			Sudbury River, from 1875 to 1900, twenty-six years. Catchment area, 78.2 square miles.[a]			Mystic Lake, from 1878 to 1895, eighteen years. Catchment area, 26.9 square miles.		
	Rain.	Run-off.	Evaporation.	Rain.	Run-off.	Evaporation.	Rain.	Run-off.	Evaporation.
Storage	23.1	14.9	8.2	23.5	17.9	5.6	22.4	15.1	7.3
Growing	11.6	2.1	9.5	10.7	1.7	9.0	10.9	2.3	8.6
Replenishing	12.4	3.3	9.1	11.9	3.0	8.9	10.8	2.6	8.2
Year	47.1	20.3	26.8	46.1	22.6	23.5	44.1	20.0	24.1

Period.	Neshaminy Creek, from 1884 to 1899, sixteen years. Catchment area, 139.3 square miles.			Perkiomen Creek, from 1884 to 1899, sixteen years. Catchment area, 152 square miles.			Tohickon Creek, from 1884 to 1898, fifteen years. Catchment area, 102.2 square miles.		
	Rain.	Run-off.	Evaporation.	Rain.	Run-off.	Evaporation.	Rain.	Run-off.	Evaporation.
Storage	23.1	17.2	5.9	23.2	16.7	6.5	24.2	20.5	3.7
Growing	13.4	2.7	10.7	13.7	3.1	10.6	14.6	3.5	11.1
Replenishing	11.1	3.2	7.9	11.1	3.8	7.3	11.3	4.4	6.9
Year	47.6	23.1	24.5	48.0	23.6	24.4	50.1	28.4	21.7

Period.	Hudson River, from 1888 to 1901, fourteen years. Catchment area, 4,500 square miles.			Pequannock River, from 1891 to 1899, nine years. Catchment area, 63.7 square miles.			Connecticut River, from 1872 to 1885, eleven years.[b] Catchment area, 10,234 square miles.		
	Rain.	Run off.	Evaporation.	Rain.	Run-off.	Evaporation.	Rain.	Run-off.	Evaporation.
Storage	20.6	16.1	4.5	23.0	19.7	3.3	18.9	15.1	3.8
Growing	12.7	3.5	9.2	12.7	3.1	9.6	13.8	3.3	10.5
Replenishing	10.9	3.7	7.2	11.1	4.0	7.1	10.3	3.6	6.7
Year	44.2	23.3	20.9	46.8	26.8	20.0	43.0	22.0	21.0

[a] See explanatory matter.

[b] Three years omitted from mean.

TABLE No. 14.—*Low-water periods on Muskingum River.*

[Catchment area=5,828 square miles.]

First period.				Second period.				Third period.			
Months.	Gross depth, in inches.	Evaporation from water surface.	Net run-off, in inches.	Months.	Gross depth, in inches.	Evaporation from water surface.	Net run-off, in inches.	Months.	Gross depth, in inches.	Evaporation from water surface.	Net run-off, in inches.
1887.											
December	0.18	0.01	0.17								
1888.											
January	1.24	.01	1.23								
February	1.12	.01	1.11								
March	1.38	.01	1.37					1894.			
April	.80	.01	.79	1891.				April	0.75	0.01	0.74
May	.45	.02	.43	May	0.45	0.02	0.43	May	.74	.02	.72
June	.29	.02	.27	June	.91	.02	.89	June	.42	.02	.40
July	.81	.03	.78	July	.51	.03	.48	July	.13	.03	.10
August	.67	.03	.64	August	.35	.03	.32	August	.11	.03	.08
September	.61	.02	.59	September	.17	.03	.14	September	.15	.03	.12
October	.77	.02	.75	October	.26	.02	.24	October	.10	.02	.08
November	2.01	.01	2	November	.94	.01	.93	November	.16	.01	.15
December	.84	.01	.83	December	1.03	.01	1.02	December	.36	.01	.35
1889.				1892.				1895.			
January	1.89	.01	1.88	January	.74	.01	.73	January	1.67	.01	1.66
February	1.42	.01	1.41	February	2.40	.01	2.39	February	.12	.01	.11
March	.71	.01	.70	March	1.26	.01	1.25	March	1.20	.01	1.19
April	.88	.01	.87	April	1.38	.01	1.37	April	.59	.01	.58
May	.28	.02	.26	May	2.25	.02	2.23	May	.10	.02	.08
June	.47	.02	.45	June	2.30	.02	2.28	June	.17	.02	.15
July	.55	.03	.52	July	.75	.03	.72	July	.21	.03	.18
August	.22	.03	.19	August	.60	.03	.57	August	.11	.03	.08

September	.14	.02	.12
October	.14	.02	.12
November	.08	.01	.07
24 months	18.55	.40	18.15

September	.28	.02	.26
October	.20	.02	.18
November	.19	.01	.18
December	.24	.01	.23
1898.			
January	.37	.01	.36
21 months	17.58	.38	17.20

September	.13	.02	.11
October	.08	.02	.06
November	.16	.01	.15
20 months	7.46	.37	7.09

TABLE NO. 15.—*Low-water periods on Genesee River.*

[Catchment area at point of gaging = 1,070 square miles; above proposed dam = 1,000 square miles.]

First period.				Second period.			
Month.	Gross depth, in inches.	Evaporation from water surface.	Net run-off, in inches.	Month.	Gross depth, in inches.	Evaporation from water surface.	Net run-off, in inches.
1894.		*Per cent.*		1896.		*Per cent.*	
June	1.10	0.05	1.05	June	0.39	0.05	0.34
July	.14	.06	.08	July	.24	.06	.18
August	.22	.07	.15	August	.20	.05	.15
September	.93	.04	.89	September	.16	.03	.13
October	.44	.03	.41	October	1.74	.02	1.72
November	.82	.02	.80	November	.82	.02	.80
December	.61	.01	.60	December	.79	.01	.78
1895.				1897.			
January	.66	.01	.65	January	.78	.01	.77
February	.22	.01	.21	February	.79	.01	.78
March	1.94	.02	1.92	March	2.65	.02	2.63
April	2.01	.03	1.98	April	1.31	.03	1.28
May	.19	.06	.13	May	.99	.06	.93
June	.13	.06	.07	June	.44	.06	.38
July	.11	.05	.06	July	.46	.06	.40
August	.12	.04	.08	August	.44	.05	.39
September	.10	.03	.07	September	.18	.04	.14
October	.11	.02	.09	October	.18	.03	.15
November	.47	.01	.46	November	.37	.02	.35
December	1.32	.01	1.41	December	.95	.01	.94
1896.							
January	.47	.01	.46				
February	.91	.01	.90				
21 months	13.02	.65	12.37	19 months	13.88	.64	13.24

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
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CALIFORNIA HYDROGRAPHY

BY

JOSEPH BARLOW LIPPINCOTT

WASHINGTON
GOVERNMENT PRINTING OFFICE
1903

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, D. C., January 15, 1903.

SIR: I have the honor to transmit herewith a paper entitled "California Hydrography," by Mr. J. B. Lippincott, containing a summary of as much of the data concerning the water supply of California as is available from printed records and from observations of other engineers and investigations made by this Survey. The published records on the subject, hitherto much scattered, some of them out of print and difficult to secure, are here brought together, and the paper should therefore form a convenient and valuable book of reference for the use of engineers, irrigators, and all who are interested in the development of the valuable water resources of California.

For convenience in the use of the book the prominent drainage basins have been placed in alphabetic order, and the minor tributaries of the larger streams have been arranged alphabetically under the name of the trunk stream into which they discharge. The minor tributaries and irrigation ditches have in addition been cross-entered in alphabetic place, so that they may be found independently under their local names. The discharge measurements include both low-water and flood records and are accompanied by useful precipitation data.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

CALIFORNIA HYDROGRAPHY.

By JOSEPH BARLOW LIPPINCOTT.

INTRODUCTION.

The purpose of this publication is to assemble under one cover as much of the data concerning the water supply of California as is available from printed records, observations of other engineers, and investigations made by this Survey. The greater portion of the data are obtained from the latter source. The records of stream flow that have been published by the United States Geological Survey appear, first, in numerous Water-Supply Papers, which are published annually, soon after the end of the year's work, and contain a brief summary of the past year's operations, and, second, in large annual reports, showing the average monthly discharge and other records of streams in all portions of the United States. Thus, while the published record is complete, it is distributed through many volumes, and numerous investigators do not have a complete set of these publications.

The methods of stream measurement practiced by the Geological Survey are fully described in Water-Supply and Irrigation Paper No. 56. In brief, they usually consist of measuring the cross section of the stream with a tape and a sounding rod, and determining the velocity at numerous points in this cross section by means of a current meter, usually of the Price type. On large streams the meter measurements are usually made from cables. On small streams they are often made from foot bridges. The velocity observed is applied to each subdivision of the cross section where it is made, and the aggregate discharge of these cross sections is taken as the total discharge of the stream. On small streams weir measurements are often made.

When a record of daily flow is to be kept on any river a gage rod is established on the stream near the point of measurement, and the height of the water on this rod is observed and recorded at the time each measurement is made. By properly selecting periods of high, low, and average water for the times of measurement it is possible to

formulate a rating or discharge curve for the river in terms of volume discharged and water height on the rod. A local observer is employed to read the rod daily, and from these observed rod readings a statement of daily, monthly, and annual discharge is deduced.

Some of the data given were contributed by irrigation and power companies from daily records kept at their head works. In cases of this kind due credit is given.

The reports compiled and published by the California State engineering department between the years 1878 and 1884[a] are now out of print and hard to obtain. The information contained in them is therefore included in this paper. The method of stream measurement most commonly practiced by the State engineering department consisted of stretching two wires across the stream at a fixed distance apart and noting the time of passage of floats through the section observed from the upper to the lower wire. Cross-sectional areas were measured and the velocities indicated by the floats were applied thereto, thus determining the discharge. Daily records of river heights on gage rods were kept on a number of the streams in a manner similar to that practiced by the United States Geological Survey. A rating table for the station was obtained from the discharge measurements, and, by applying it to the daily rod readings, monthly and annual discharge tables were determined. In several instances, however, where records have been kept on neighboring streams the State engineering department has prepared theoretical discharge estimates of other streams in the same locality by using the rate of run-off per square mile obtained from a measured stream and applying it in determining the probable run-off from the basin of a neighboring stream. In cases of this kind the discharge figures are marked with a star. In each instance the effort has been made to give the date of the measurement, the name of the observer, the volume discharged, and a description of the locality and stream.

The measurements have been grouped in the principal drainage basins, but it would obviously be impossible to adhere rigidly to this arrangement. For instance, all the streams of the San Joaquin Valley are, technically speaking, tributary to San Joaquin River, but it would be manifestly improper to include all the main rivers from the Sierras in this section under the head of San Joaquin River. The rule therefore has been adopted of giving each prominent drainage basin its place in alphabetic sequence; the minor tributaries of these large streams are then arranged alphabetically under the name of the trunk stream into which they discharge. For instance, Tuolumne River is considered an independent stream, but Eleanor Creek, Falls Creek, etc., are considered minor tributaries and are arranged under the heading "Tuolumne River." The effort has been made, however,

[a] No measurements were made by the California State engineering department subsequent to 1884, as the office was then discontinued.

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to cross-enter all these minor tributaries, so that they may be found independently under their local names, reference being made to the trunk stream into which they discharge.

Undoubtedly many measurements that are not available for this publication have been made for corporations and individuals by engineers of California. These data, if they could be obtained, would doubtless be of great value, and the suggestion is here made that it would be a public benefit to send this information to the United States Geological Survey, where it would be available for publication in subsequent bulletins of this nature.

The records of the Signal Service and Weather Bureau are also contained in annual reports extending over a long term of years, and the engineer who possesses a complete file of these publications is indeed fortunate.

The rain water which forms the source of the water supply for agriculture in California falls in large part upon the mountain ranges of the State. It is a well-known fact that within the State there are vast differences in rainfall with increase or decrease of elevation, particularly on the western slopes of the mountain ranges. Rainfall statistics have been compiled in great mass for the valley districts, where farming is actually carried on, but the engineer who is investigating plans for storage and power is much more interested in the rainfall of the mountains. An attempt has been made to include in this paper all available data relative to precipitation at the higher elevations. The Weather Bureau publishes its records of precipitation in calendar years, beginning with the 1st of January, which is the middle of the rainy season on the California coast. A record beginning on the 1st of January may show for that and following months conditions of excessive drought, while for the following November and December of the same calendar year it may give records of excessive rainfall, the result indicated for the calendar year being a mean rainfall, whereas there may have been a dry season followed by one of excessive precipitation. For this reason the rainfall records for the mountain districts have been classified in seasonal years, and it is believed that their presentation in this form will avoid for the engineer many laborious retabulations of results. Particular effort has been made to collect and present new data.

Each table of precipitation is accompanied with a statement showing the approximate position of the station and its elevation, as well as the authority for the record. These records are in part taken from the annual reports of the Weather Bureau and rearranged in seasonal instead of calendar years, as stated above. All the regular stations of the United States Weather Bureau are situated at relatively low elevations with the exception of Mount Tamalpais, but some voluntary observers report to the Weather Bureau from mountain sta-

tions. These observers use a variety of measuring devices. Some use glass graduates, with various-sized catchment cups, and some employ more primitive implements. The records of mountain precipitation, however, are so scarce that they are all given here, because it is believed that any information tending to throw light on this subject is of value.

All the records that are credited to the Southern Pacific Railroad were obtained from Mr. William Hood, chief engineer of the system. The rain gages used by the railroad company are small gages with 3-inch catchment cups, usually set on posts about 6 feet in height, and the observations are made by the local railroad agents. Their reports are sent in promptly to San Francisco and are there tabulated by a corps of clerks whose time is devoted entirely to this subject.

In many places in the high mountain districts, particularly at the greatest elevations, the gages have been lately furnished by the hydrographic branch of the United States Geological Survey. The gages used in these places are of the standard type, with an 8-inch measuring cup. Snow observations are made by melting the snow and reporting the resultant water.

RELATION OF RAINFALL TO RUN-OFF IN CALIFORNIA.

DIAGRAMS AND TABLES.

The accompanying diagrams and tables are presented as the result of a study of the available rainfall and run-off data for California watersheds.

As the run-off diagram was to be used in estimating the water supply available for various storage reservoirs for irrigation, it was thought best to represent the run-off in acre-feet per square mile. The majority of the discharge reports give the depth of run-off in inches. The accompanying table has been made for converting depth of run-off in inches to run-off in acre-feet per square mile, the following formula being used:

Depth of run-off in inches $\times (0.0833 \times 640) =$ run-off in acre-feet per square mile.

Table for converting depth of run-off in inches into acre-feet per square mile.

Depth of run-off.	Acre-feet per square mile.	Depth of run-off.	Acre-feet per square mile.	Depth of run-off.	Acre-feet per square mile.	Depth of run-off.	Acre-feet per square mile.
Inches.		*Inches.*		*Inches.*		*Inches.*	
0.01	0.533	0.26	13.867	0.51	27.200	0.76	40.533
.02	1.067	.27	14.400	.52	27.733	.77	41.067
.03	1.600	.28	14.933	.53	28.267	.78	41.600
.04	3.133	.29	15.467	.54	28.800	.79	42.133
.05	2.667	.30	16.000	.55	29.333	.80	42.667
.06	3.200	.31	16.533	.56	29.867	.81	43.200
.07	3.733	.32	17.067	.57	30.400	.82	43.733
.08	4.267	.33	17.600	.58	30.933	.83	44.267
.09	4.800	.34	18.133	.59	31.467	.84	44.800
.10	5.333	.35	18.667	.60	32.000	.85	45.333
.11	5.867	.36	19.200	.61	32.533	.86	45.867
.12	6.400	.37	19.733	.62	33.067	.87	46.400
.13	6.933	.38	20.267	.63	33.600	.88	46.933
.14	7.467	.39	20.800	.64	34.133	.89	47.467
.15	8.000	.40	21.333	.65	34.667	.90	48.000
.16	8.533	.41	21.867	.66	35.200	.91	48.533
.17	9.067	.42	22.400	.67	35.733	.92	49.067
.18	9.600	.43	22.933	.68	36.267	.93	49.600
.19	10.133	.44	23.467	.69	36.800	.94	50.133
.20	10.667	.45	24.000	.70	37.333	.95	50.667
.21	11.200	.46	24.533	.71	37.867	.96	51.200
.22	11.733	.47	25.067	.72	38.400	.97	51.733
.23	12.267	.48	25.600	.73	38.933	.98	52.267
.24	12.800	.49	26.133	.74	39.467	.99	52.800
.25	13.333	.50	26.667	.75	40.000	1.00	53.333

At the outset many difficulties presented themselves. The most serious one was that of obtaining measurements of rainfall at the higher elevations. The streams having the largest run-off, and on which discharge records had been kept, have their sources on the western slopes of the high Sierra Nevada, where there are few or no inhabitants above 7,000 feet, and consequently no observers of rainfall; but the valuable rainfall records of the Pacific Railway system along the line of railway from Sacramento to the summit of the Sierra Nevada at Railroad Pass offered a solution of this difficulty. In fig. 1 the mean rainfall and the elevation of the station are plotted as ordinates, and the distance inland of the station as abscissas.

The rate of increase of precipitation from Sacramento to Cisco, at the elevation of 6,000 feet, the point of maximum rainfall, seems to

be 0.6 inch per 100 feet of rise. The precipitation above the 6,000-foot point decreases with the elevation approximately at the rate of 0.4 inch per 100 feet of rise.

Fortunately, in Tuolumne River Basin, about midway between American and King river basins, there is another series of rainfall stations, including Lagrange, elevation 293 feet above sea level; Sonora, elevation 1,824 feet; Second Garrote, elevation 2,900 feet, and Crockers, elevation 4,453 feet. The mean rainfall of these stations, plotted as in the above diagram, indicates the rate of increase from Lagrange to Crockers to be 0.84 inch per 100 feet of rise. This rate of increase has been taken to hold good up to an elevation of 6,000 feet, and above this the rate of decrease of rise to be 0.4 inch per 100 feet to an elevation of 9,000 feet. Probably the rate of increase and

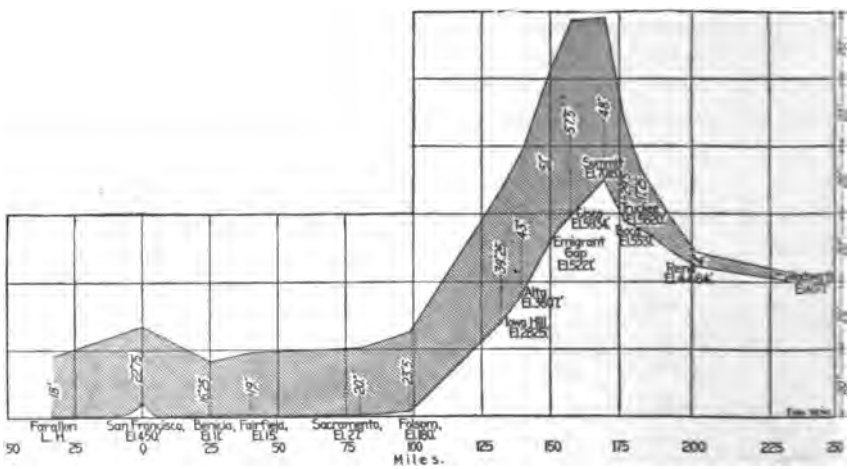

FIG. 1.—Diagram showing increase of rainfall with rise in elevation over the Sierras in central California.

decrease would be more correctly represented by a curved line, but the data are not sufficient to warrant such representation.

At these rates of increase and decrease, the mean precipitation for the years 1896–1899, at an elevation of 9,000 feet in the Tuolumne River Basin, would be 49.8 inches; if snow converts into water at the ratio of 8 to 1, the snowfall would be 33.2 feet at this elevation.

It was found impossible to use the run-off data of Kern River Basin—though that stream is without doubt more closely watched than any other stream in the State and the record is the oldest for any large stream in the State—because of the exposure of the watershed and because of the scarcity of rainfall data. This watershed is bounded on the west for almost its entire length by a high mountain range. Concerning the precipitation on the eastern slope of this range, little is known beyond the fact that it is very much less than on the western slope.

In 1896 the total run-off from King River Basin, comprising 1,775 square miles, was 1,871,005 acre-feet. For the same year the run-off from Kern River Basin was 619,630 acre-feet. The ratio of the area of King River Basin to Kern is 1 to 1.32, and the ratio of run-off, 1 to 0.33, though the higher drainage areas of the streams are contiguous. It was also thought best not to use the run-off and rainfall data for Piru Creek Basin, furnished by the Antelope Valley Water Company, because the ratio of discharge in acre-feet per square mile was greater than any other record. There is little doubt about the accuracy of both the run-off and precipitation records, the explanation being that the rainfall observation stations were necessarily situated at so low an elevation that the record did not represent the mean rainfall for the higher portions of the basin.

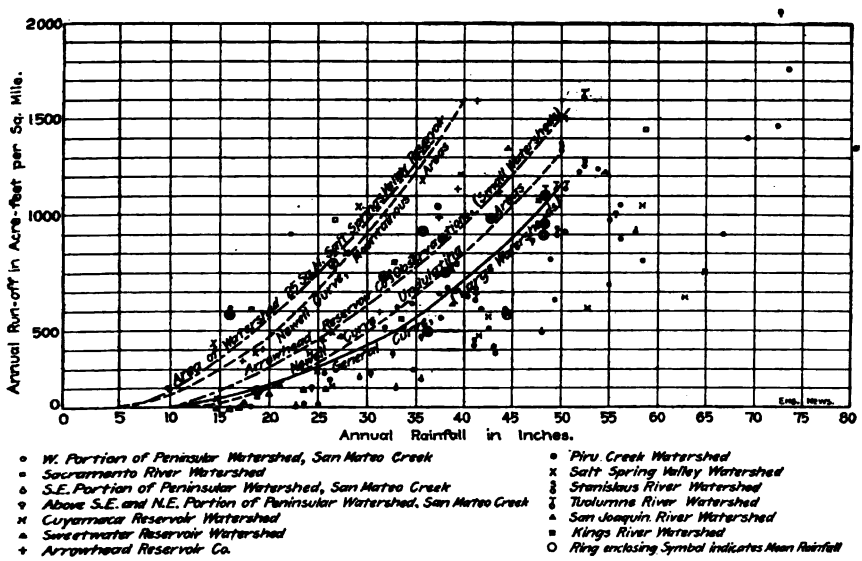
Annual Run-off in Acre-feet per Sq. Mile.
2000
1500
1000
500
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80
Annual Rainfall in Inches.
W. Portion of Peninsular Watershed, San Mateo Creek
Sacramento River Watershed
S.E. Portion of Peninsular Watershed, San Mateo Creek
Above S.E. and N.E. Portion of Peninsular Watershed, San Mateo Creek
Cuyamaca Reservoir Watershed
Sweetwater Reservoir Watershed
Arrowhead Reservoir Co.
Piru Creek Watershed
Salt Spring Valley Watershed
Stanislaus River Watershed
Tuolumne River Watershed
San Joaquin River Watershed
Kings River Watershed
Ring enclosing Symbol indicates Mean Rainfall

FIG. 2.—Annual and mean run-off from California watersheds, based on several years' observations.[a]

The run-off and rainfall data of the streams which were used to make the discharge diagram, fig. 2, will be mentioned in the order from north to south in which their watersheds occur.

STATISTICS BY BASINS.

Sacramento River Basin.—The rainfall stations used in determining the mean annual precipitation for Sacramento River Basin were the following: Red Bluff, Rosewood, Redding, Delta, Dunsmuir, Shasta, Sisson, and Fort Bidwell.

There were absolutely no records for the great interior mountain-

[a] For derivation of "Newell curves," see Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1894, p. 151.

ous and lava country in Siskiyou, Modoc, and Lassen counties, comprising more than 5,334 square miles of the watershed.

Fort Bidwell is situated outside of the watershed, on the eastern slope of the mountains that form the boundary, and would probably have a less rainfall than Modoc County. The record was kept there for a period of twenty-two years, and the mean rainfall is 20.8 inches.

The average rainfall at Red Bluff for a period of twenty-three years was 23.9 inches; at Rosewood, for a period of six years, 25.63; at Redding, for twenty-four years, 35.69 inches. The precipitation at these three latter stations was taken to get the average for Sacramento Valley for the years 1896-1899, during which years run-off measurements were made at Jellys Ferry. The mean rainfall of Pit River drainage area (5,334 square miles), which has an average elevation of 5,000 feet, was taken to be the same as that of the Sacramento Basin above Red Bluff.

The average rainfall at Delta for a period of fourteen years was 62.39 inches; at Dunsmuir, for ten years, 57.16 inches; at Shasta, for six years, 53.26 inches; at Sisson, for ten years, 32.75 inches. The rainfall at these four stations was taken to obtain the mean rainfall for the mountainous area of the watershed for the years 1896–1899.

San Mateo Creek.—The Spring Valley Water Company's record of rainfall and run-off from the watershed of San Mateo Creek is without doubt the oldest record in the State, having been kept for thirty years. In the table given on page 390 of Water-Supply and Irrigation Paper No. 38 of the United States Geological Survey, no allowance has been made for evaporation from the surface of the reservoir; 20 per cent has here been added to the run-off as calculated from those tables to cover evaporation. The drainage basin of San Mateo Creek ranges in elevation from 250 to 1,800 feet, with an average of about 750 feet. The hills are undulating. There is a limited growth of timber on the northern slopes near the summit, but a large amount of brush covers other portions of the basin. On the southern slopes and crest the hills are frequently bare of brush, but are covered with grasses.

Salt Springs Valley watershed.—The basin of Salt Springs Valley is largely of red clay, which scantily covers a bed rock of granite and slate. The topography is undulating rather than mountainous, about 20 per cent of the total drainage area being valley land. There is little brush or timber in the valley, and only a scattered growth of oak and scrubby pine on the hills. To obtain the mean for the basin 7 per cent has been added to the rainfall for North Hill, 6 miles northwest of the dam. To obtain the total run-off for the basin 4,132 acre-feet have been added to the amounts given in the table on page 337, Part IV, of the Eighteenth Annual Report of the United States Geological Survey, to compensate for evaporation from the reservoir surface.

The methods of measurement of discharge from the reservoir and

very crude, and this may partly account for the very high percentage of run-off from this basin, which contains 25 square miles.

Stanislaus River Basin.—No rainfall data were obtained for this basin, but since it joins the Tuolumne and is in most respects similar to that, the rainfall for Tuolumne Basin has been taken to apply to both.

Tuolumne River Basin.—To obtain the mean rainfall for this basin the average elevations and the areas of the various portions were taken from the topographic maps of the United States Geological Survey. The areas were obtained by the use of a planimeter. La Grange was taken as the base station, and the percentage of increase for the various elevations is shown by the diagram, fig. 1. The following example, for the year 1896, will illustrate more particularly the method:

Table of estimated rainfall, Tuolumne River Basin.

Average elevation.	Number of square miles.	Estimated rainfall, 1896.	Mile-inches.
1,200	75	26.4	1,980
1,500	88	29.0	2,552
2,500	182	37.4	6,807
3,500	46	45.8	2,107
4,000	105	50.0	5,252
4,500	147	54.2	7,967
5,500	90	60.9	5,481
6,000	143	63.3	9,052
6,500	105	61.3	6,437
7,500	189	57.3	10,830
9,000	330	51.3	16,927
1,500	.....	.....	75,692

$\frac{75,692}{1,500} = 50.3$ inches mean for basin, 1896.

San Joaquin and King river basins.—There were practically no rainfall data for either San Joaquin or King River Basin.

The estimated mean rainfall for Tuolumne River Basin for the years 1896–1899 is 48.2 inches; the depth of mean run-off for the same period is 20.8 inches; the depth of mean run-off for San Joaquin River for this period is 18.4 inches. Since the topography, exposure, etc., in the two basins are similar, the rainfall will probably be proportional to the run-off.

Example, 20.8 : 18.4 : : 48.2 : 42.7. Similarly, the mean rainfall for King River Basin will be 37.8 inches.

Mohave River.—The meteorologic and hydrographic work of the Arrowhead Water Company has been carried on for a number of years at the head of Mohave River. Twenty-eight rain gages, carefully located at elevations of from 2,100 to 7,200 feet, have been maintained. The measurements of run-off from several tributaries have been made over weirs. The areas of the basins are each less than 50 square miles. The watershed is covered with a thick growth of timber on the crest. The growth of timber diminishes as the desert is approached, the northern part of the watershed being covered with brush only. The mean elevation of the watershed above sea level is about 5,250 feet.

Cuyamaca reservoir watershed—The area of this watershed is 11 square miles and the mean elevation above sea-level is probably 5,500 feet.

The run-off is carefully measured. There is only one rain gage maintained, and that is at the dam. The resident engineer, Mr. F. S. Hyde, says that as this rain gage is located between two high wooded peaks, which act as condensers of the moisture-laden clouds, the recorded precipitation is undoubtedly heavier than the average of the watershed. This probably explains why the mean annual run-off is so far below the general curve.

Sweetwater reservoir basin—The evaporation and run-off records from this basin date from 1888, and have been very carefully kept.

There is no doubt that many of the points on the curves (fig. 2) would be changed if we had more definite information as to the rainfall, but the curves are the best that could be made from the information at hand. The mean discharge for the period of observation on each stream is used, together with the mean rainfall for the same years. These means are considered the more satisfactory, as they tend to eliminate erratic stream and rainfall records.

EVAPORATION.

LAKE TAHOE.

On May 17, 1900, a galvanized-iron tank, 2 feet square and 2 feet deep, was placed in Lake Tahoe at its outlet, where it would be protected from the heavy waves of the lake, for the purpose of measuring the evaporation from the lake surface. A finely divided scale was placed in this tank, and daily readings taken at about the same hour of each day by Mr. J. U. Haley, general freight and passenger agent of the Lake Tahoe Railway and Transportation Company. The tank was at all times kept full to within 1 or 2 inches of the top, and was floated by means of a timber frame, which also served as a protection from waves and drift, so that the water level inside and outside was about the same. The depth of water in which the tank was anchored was about 6 feet, and the water in the tank was fully exposed to wind and

sun. The following table shows the monthly evaporation from May 17 to November 30.[a]

Evaporation at Lake Tahoe, as measured in tank in lake at Tahoe City.

Date.	Depth in inches.
1900.	
May 17 to 31	1.83
June	3.80
July	4.00
August	5.15
September	3.10
October	2.15
November	1.38
Total	21.41

While it is possible that the evaporation from the lake surface was somewhat greater than from the tank, owing to its greater roughness and consequent greater surface, relatively, in contact with the air during high winds, it is believed that the results here given are as near to the truth as it is possible to attain, and that they represent very closely the loss of water which may be expected from evaporation from natural lakes or storage reservoirs situated at about 6,000 feet altitude in this portion of the Sierras during the period over which the record extends.

RENO, NEV.

During the year 1894, from May 11 to November 30, a series of observations were made at Reno, Nev., with a view to determining approximately the depth of evaporation at that point. For this purpose a small galvanized-iron tank, 18 inches square and 18 inches deep, was sunk in the ground until the rim was but half an inch above the surface. This was kept filled to within less than 1 inch of the top at all times and was so placed that it was fully exposed to the sun and wind. The earth immediately around the tank was kept wet. The results, while not absolutely reliable as an index to the actual evaporation from a lake reservoir or canal surface, are believed to be a fairly close approximation to what would occur from such a surface at Reno, and since the conditions influencing evaporation—temperature, humidity of atmosphere, winds, etc.—over the lower portion of the Truckee River Basin are nearly identical with those at Reno, they should be roughly applicable to other points in that portion of the basin.

[a] Taylor, H. L., Water storage in the Truckee Basin: Water-Sup. and Irr. Paper No. 68, U. S. Geol. Survey, 1902.

Evaporation from tank in earth at Reno, Nev.

Date.	Depth in inches.
1894.	
May 11 to 31	2.80
June	5.35
July	8.45
August	9.12
September	7.44
October	4.31
November	2.75
Total	40.22

SWEETWATER RESERVOIR.

The following table shows the amount of evaporation, wind movement, humidity, and temperature at Sweetwater reservoir for a series of years:

Annual evaporation, temperature, etc., in Sweetwater Basin, San Diego County.

[Elevation of reservoir, 250 feet.]

Period.	Evaporation.	Wind.	Humidity.	Temperature of air.	Temperature of water.
	Inches.	*Miles per hour.*	*Per cent.*	*°F.*	*°F.*
1889–90	56.47	4.9			
1890–91	57.54	4.6			
1891–92	58.65	4.8	72	61	6
1892–93	49.60	4.9	68	61	6
1893–94	48.68	5.1	70	60	6
1894–95	46.31	5.2	79	59	
1895–96	45.18	5.2	71	61	
1896–97	[a]41.24	5.3	76	61	
1897–98	61.93	5.9	73	60	
1898–99	[b]32.54	5.8	72	59	

[a] Evaporation January 1 to August 31. [b] Evaporation September 1 to April 30.

KERN AND TULARE COUNTIES.[a]

To ascertain the amount of evaporation from exposed surfaces of water, experiments have been made in Kern County at various points and in Tulare County at Kingsburg.

The experiments in Kern County commenced in the latter part of

[a] Authority, Physical Data and Statistics of California.

June, 1879, and were continued at several localities through July, August, and September, the three hottest months of the year. Subsequently observations were made until December 20, 1879, at Rio Bravo ranch, about 10 miles east of Bakersfield. The experiments at Kingsburg, Tulare County, commenced on November 1, 1881, and were continued to November 1, 1885.

In making the Kern County experiments pans of galvanized iron 2 feet square and 1 foot deep were used, some of the observations being made in pans floated in large bodies of water, and others in pans set in open ground, as will be explained more fully for each of the records.

The pans used in making the later observations at Kingsburg were 3 feet square and 15 inches deep. The water surface was maintained about 5 inches below the rim of the pan.

The amount of water required from time to time to maintain its surface in the pans at a fixed height was measured in standard cups prepared for the purpose and graduated to represent depth of water in the pan for which they were used.

When floated in a lake or river the pans were protected from the splash of waves. The contrivance used in King River, at Kingsburg, for this purpose was a large wooden frame, into which the pan was fitted so as to float horizontally, but not be protected from the sun or movement of the air.

Observers at Kingsburg were instructed, among other things—

To fill the pan to the normal plane once every day during the summer months; less frequently at other seasons of the year.

To take an observation at the commencement of every fall of rain, and to restore the water surface to the normal plane at the end of every fall of rain.

To keep a daily record of the temperature of the air, of the water in the pan, and of the water surrounding the pan.

To keep a rainfall record.

The earlier observations made in Kern County were conducted less systematically, but still with sufficient care and thoroughness to serve a good purpose.

The results of the observations made in Kern County are embodied in Tables No. 1 to 6, which are a rearrangement of data published by the State engineering department in the report of 1880.

In Table No. 1 are given the results of the experiment made in Reeder Lake, which is a narrow body of water, 12 to 15 feet deep, surrounded by large cottonwood trees and willows. The pan was placed in a shallow arm of the lake, fully exposed to the sun, but protected from the wind.

Panama Slough (see Table No. 2) was selected for another set of observations. The pan was placed in running water 10 feet deep, showing a much lower temperature than Reeder Lake. It was fully exposed to the sun, but protected from the wind.

The pan in the center of Kern Lake (Table No. 3) was about 2 miles from shore, in 5 feet of water. On September 5, 13, and 29 the wind was northwest; on September 19 it was southwest.

The pan near the shore of Kern Lake (Table No. 4) was placed on the northeast side of the lake, in about 2 feet of water.

In Tables No. 5 and 6 are given the results of observations made at the Rio Bravo ranch, 3 miles below the mouth of Kern River Canyon. The pan in Kern River was freely exposed to sun and wind, but was immersed in water to within 2 inches of its top. The pan placed on top of the ground was free to the action of all elements, producing extreme evaporation.

In Tables No. 7 to 11 are presented, in condensed form, the results of observations covering a period of four years. The total depth of water evaporated during each month, each period of three months, and each year is given in a separate table for each of the four years. The tables contain also the averages of daily temperature records.

Table No. 11 is one of averages, in which columns are added, showing the rate of evaporation per twenty-four hours, and the amount evaporated per second per square mile, during the different time periods.

The pan in the air referred to in the Kingsburg tables was, after the first three months, set into the ground, earth being banked up around its sides to the same elevation as the water in it. Its surface was fully exposed to sun and wind. During November and December, 1881, and January, 1882, this pan was on the railroad bridge, exposed on all sides to sun and air.

Evaporation at several points in Kern County, June to December, 1879.

TABLE NO. 1.—PAN IN REEDER LAKE.

Date.	Time of day.	Temperature (degrees F.).			Evaporation (depth in feet).	Evaporation per 24 hours (depth in feet).	Evaporation in cubic feet per second per square mile.
		Water in pan.	Water surrounding pan.	Air.			
1879.							
June 23	9.55 a. m.	.....	.....	.....	.....	.....	.....
June 23 to 25	6.25 a. m.	83	.....	92	0.040	0.0168	5.42
June 25 to 28	7.50 p. m.	81	.....	90	.068	.0222	7.13
June 28 to 30	5 p. m.	82	.....	79	.035	.0187	6.04
June 30 to July 5	4.50 p. m.	87	.....	73	.096	.0192	6.20
July 5 to 8	5 p. m.	92	.....	77	[a].072	[a].0240	[a]7.74
June 23 to July 8.	.....	.....	.....	.....	.311	.0203	6.56

[a] Water fell, leaving the pan at the top 6 inches above water surface.

Evaporation at several points in Kern County, June to December, 1879—Cont'd.

TABLE NO. 2.—PAN IN PANAMA SLOUGH.

Date.	Time of day.	Temperature (degrees F.).			Evaporation (depth in feet).	Evaporation per 24 hours (depth in feet).	Evaporation in cubic feet per second per square mile.
		Water in pan.	Water surrounding pan.	Air.			
1879.							
July 9	12.30 p. m						
July 9 to 11	6.20 p. m	72		76	0.030	0.0134	4.34
July 11 to 21	9 a. m						
July 21 to 24	6.50 p. m			88	.037	.0108	3.48
July 24 to 29	6.15 p. m	76	71	88	.054	.0108	3.48
July 29 to August 5.	7 p. m	79	77	92			
August 5 to 13	7 a. m	72	74	76			
August 13 to 20	6.45 a. m	64	67	68	.084	.0120	3.87
July 9 to August 20.					[a].490	[a].0116	[a]3.74

[a] Approximate.

TABLE NO. 3.—PAN IN CENTER OF KERN LAKE.

1879.							
August 30	10.40 a. m	88	86	90			
August 30 to September 5.	11.30 a. m	89	81	90	0.105	0.0175	5.63
September 5 to 13	12.30 p. m	86	86	118	.096	.0119	3.90
September 13 to 19	12.05 p. m	86	86	120	.150	.0250	8.08
September 19 to 29	12.10 p. m	78	78	88	.180	.0180	4.80
August 30 to September 29.					.531	.0173	5.70

TABLE NO. 4.—PAN NEAR SHORE OF KERN LAKE.

1879.							
August 14	10.40 a. m						
August 14 to 30	10.40 a. m	88	86	90	0.480	0.0300	9.67
August 30 to September 5.	11.10 a. m	79	83	90	.201	.0334	9.31
September 5 to 13	12 m	88	90	118	.195	.0242	7.81
September 13 to 19	12 m	81	89	120	.156	.0259	8.36
September 19 to 29	12 m	76	80	88	.189	.0190	6.13
August 14 to September 29.					1.221	.0265	8.55

Evaporation at several points in Kern County, June to December, 1879—Cont'd.

TABLE No. 5.—PAN IN KERN RIVER AT THE RIO BRAVO RANCH.

Date.	Time of day.	Temperature (degrees F.).			Evaporation (depth in feet).	Evaporation per 24 hours (depth in feet).	Evaporation in cubic feet per second per square mile.
		Water in pan.	Water surrounding pan.	Air.			
1879.							
October 2							
October 2 to 11	4 p. m.	66	64	74	0.104	0.0116	3.73
October 11 to 18	4 p. m.	68	66	84			
October 18 to 25	4 p. m.	68	66	78	.052	.0074	2.38
October 25 to November 1.	4 p. m.	62	61	67	.052	.0074	2.38
November 1 to 8	4 p. m.	55	55	63	.045	.0064	2.06
November 8 to 15	4 p. m.	56	56	62			
November 15 to 22	4 p. m.	54	54	64	.030	.0043	1.38
November 22 to 29	4 p. m.	53	53	68	.030	.0043	1.38
November 29 to December 6.	4 p. m.	52	52	54	.030	.0043	1.38
December 6 to 13	4 p. m.	50	50	54	.030	.0043	1.38
December 13 to 20	4 p. m.	52	52	54	.030	.0043	1.38
October 2 to December 20.					[a].408	[a].0052	[a]1.67

[a] Approximate.

TABLE No. 6.—PAN ON OPEN GROUND AT THE RIO BRAVO RANCH.

1879.							
October 2	7 a. m.						
October 2 to 3	1 p. m.	68		94	0.037	0.0292	9.40
October 3 to 11	4 p. m.	68		74	.148	.0180	5.80
October 11 to 18	4 p. m.	80		84	.071	.0101	3.25
October 18 to 25	4 p. m.	78		78	.147	.0210	6.76
October 25 to November 1.	4 p. m.	70		67	.148	.0211	6.79
November 1 to 8	4 p. m.	58		63	.113	.0176	3.46
November 8 to 15	4 p. m.	65		62	.030	.0043	1.38
November 15 to 22	4 p. m.	64		64	.070	.0100	3.22
November 22 to 29	4 p. m.	62		68	.052	.0074	2.38
November 29 to December 6.	4 p. m.	58		54	.015	.0021	.68
December 6 to 13	4 p. m.	55		54	.037	.0053	1.71
December 13 to 20	4 p. m.	55		54	.037	.0053	1.71
October 2 to December 20.					.906	.0115	3.70

Evaporation at Kingsburg Bridge, King River.

TABLE No. 7.—NOVEMBER 1, 1881, TO OCTOBER 31, 1882.

[Elevation 297 feet.]

Date.	Time of day.	Temperature of air.	Pan in river.			Pan in air.	
			Temperature of water in river.	Temperature of water in pan.	Evaporation (depth in feet).	Temperature of water in pan.	Evaporation (depth in feet).
1881.							
November	4.30 p. m	66	56	55	0.220	60	0.335
December	4.30 p. m	55	52	52	.050	55	.120
1882.							
January	4.30 p. m	54	52	50	.090	53	.200
February	5 p. m	56	55	54	.115	56	.105
March	5.15 p. m	64	60	59	.180	66	.265
April	5.15 p. m	73	63	62	.260	72	.435
May	5.45 p. m	84	63	63	.305	77	.835
June	6.30 p. m	88	67	68	.475	83	.940
July	6.30 p. m	98	80	81	.660	91	1.075
August	6 p. m	96	84	85	.665	85	.875
September	6 a. m	81	73	73	.475	75	.575
October	10 a. m	68	63	63	.135	60	.195
November to January.[a]					.360		.655
February to April[b]					.555		.805
May to July[c]					1.440		2.850
August to October.[d]					1.275		1.645
Total, November to October.					3.630		5.955

[a] First period. [b] Second period. [c] Third period. [d] Fourth period.

Evaporation at Kingsburg Bridge, King River—Continued.

TABLE NO. 8.—NOVEMBER 1, 1882, TO OCTOBER 31, 1883.

Date.	Time of day.	Temperature of air.	Pan in river.			Pan in air.	
			Temperature of water in river.	Temperature of water in pan.	Evaporation (depth in feet).	Temperature of water in pan.	Evaporation (depth in feet).
1882.							
November	10 a. m.	53	52	52	0.115	49	0.100
December	10 a. m.	51	50	50	.085	46	.090
1883.							
January	10 a. m.	43	44	43	.060	41	.040
February	10 a. m.	54	50	49	.100	52	.070
March	10 a. m.	69	63	62	.305	60	.310
April	10 a. m.	67	61	62	.270	61	.260
May	10 a. m.	76	61	63	.160	67	.310
June	10 a. m.	92	68	71	.500	77	.850
July	10 a. m.	96	82	84	.760	78	.970
August	10 a. m.	93	82	83	.920	75	.970
September	10 a. m.	88	78	79	.730	73	.705
October	10 a. m.	69	62	62	.400	57	.290
November to January.[a]	10 a. m.	49	49	48	.260	45	.230
February to April[b]	10 a. m.	63	58	58	.675	58	.640
May to July[c]	10 a. m.	88	70	73	1.420	74	2.130
August to October.[d]	10 a. m.	83	74	75	2.050	68	1.965
Total, November to October.	10 a. m.	71	63	64	4.405	61	4.965

[a] First period. [b] Second period. [c] Third period. [d] Fourth period.

Evaporation at Kingsburg Bridge, King River—Continued.

TABLE No. 9.—NOVEMBER 1, 1883, TO OCTOBER 31, 1884.

Date.	Time of day.	Pan in river.				Pan in air.	
		Temperature of air.	Temperature of water in river.	Temperature of water in pan.	Evaporation (depth in feet).	Temperature of water in pan.	Evaporation (depth in feet).
1883.							
November	10 a. m	59	55	54	0.170	52	0.140
December	10 a. m	49	48	47	.080	44	.065
1884.							
January	9 a. m	47	48	48	.105	44	.075
February	9 a. m	52	52	52	.050	49	.060
March	9 a. m	61	56	57	.090	57	.105
April	9 a. m	67	60	61	.160	61	.180
May	9 a. m	76	59	61	.320	69	.400
June	9 a. m	77	57	60	.295	61	.505
July	9 a. m	83	61	63	.380	73	.670
August	9 a. m	78	64	66	.370	69	.670
September	9 a. m	75	63	63	.320	64	.520
October	9 a. m	68	62	63	.350	60	.310
November to January[a]					.355		.280
February to April[b]	9 a. m	60	56	57	.300	56	.345
May to July[c]	9 a. m	79	59	61	.995	68	1.575
August to October[d]	9 a. m	74	63	64	1.040	64	1.500
Total, November to October					2.690		3.700

[a] First period. [b] Second period. [c] Third period. [d] Fourth period.

Evaporation at Kingsburg Bridge, King River—Continued.

TABLE No. 10.—NOVEMBER 1, 1884, TO OCTOBER 31, 1885.

Date.	Time of day.	Temperature of air.	Pan in river.			Pan in air.	
			Temperature of water in river.	Temperature of water in pan.	Evaporation (depth in feet).	Temperature of water in pan.	Evaporation (depth in feet).
1884.							
November	9 a. m.	58	58	57	0.200	55	0.120
December	9 a. m.	50	48	47	.180	48	.140
1885.							
January	9 a. m.	48	50	49	.010	47	.010
February	9 a. m.	54	53	53	.140	51	.130
March	9 a. m.	65	60	60	.240	59	.220
April	9 a. m.	68	62	63	.160	63	.270
May	9 a. m.	75	63	65	.340	68	.660
June	9 a. m.	77	65	68	.660	71	.810
July	9 a. m.	84	72	74	.710	74	.900
August	9 a. m.	86	72	72	.930	72	.930
September	9 a. m.	79	74	74	.640	71	.660
October	9 a. m.	71	67	66	.470	63	.360
November to January.[a]	9 a. m.	52	52	51	.390	50	.270
February to April[b]	9 a. m.	62	58	60	.540	58	.620
May to July[c]	9 a. m.	79	67	69	1.710	71	2.370
August to October.[d]	9 a. m.	79	71	71	2.040	69	1.950
Total, November to October.	9 a. m.	63	62	63	4.680	62	5.210

[a] First period. [b] Second period. [c] Third period. [d] Fourth period.

Evaporation at Kingsburg Bridge, King River—Continued.

TABLE NO. 11.—NOVEMBER 1, 1881, TO OCTOBER 31, 1885.

[Average for four years.]

Date.	Pan in river.			Pan in air.		
	Evaporation (depth in feet).	Evaporation per 24 hours (depth in feet).	Evaporation in cubic feet per second per square mile.	Evaporation (depth in feet).	Evaporation per 24 hours (depth in feet).	Evaporation in cubic feet per second per square mile.
November	0.176	0.0059	1.89	0.174	0.0058	1.87
December	.099	.0032	1.03	.104	.0034	1.08
January	.066	.0021	.69	.081	.0026	.84
February	.101	.0036	1.16	.091	.0033	1.05
March	.204	.0066	2.12	.225	.0073	2.34
April	.213	.0071	2.29	.286	.0095	3.08
May	.281	.0091	2.93	.551	.0178	5.74
June	.483	.0161	5.20	.776	.0259	8.35
July	.628	.0203	6.54	.904	.0292	9.41
August	.721	.0233	7.51	.861	.0278	8.96
September	.541	.0180	5.82	.615	.0205	6.62
October	.339	.0109	3.53	.289	.0093	3.01
November to January [a]	.341	.0037	1.20	.359	.0039	1.26
February to April [b]	.518	.0058	1.88	.603	.0068	2.19
May to July [c]	1.391	.0151	4.88	2.231	.0243	7.83
August to October [d]	1.601	.0174	5.61	1.765	.0192	6.19
Total November to October	3.851	.0106	3.40	4.958	.0136	4.38

[a] First period. [b] Second period. [c] Third period. [d] Fourth period.

CLEAR LAKE, LAKEPORT, CAL.

Evaporation records have been kept by the United States Geological Survey at Lakeport, Cal., on Clear Lake, since February 1, 1901. The evaporation pan is 3 feet square and 1.5 feet deep, and is floated on a triangular raft anchored in a cove where it is not exposed to the full force of the wind. Evaporation observations were begun on the

land at the same point September 15, 1901. Capt. D. C. Rumsey is the observer. The following table gives the evaporation by months:

Evaporation record of Clear Lake, Lakeport, Cal.

1901.	Lake.	Land.	1902.	Lake.	Land.
January	[a] 0.85		January	0.85	0.85
February	.95		February	.25	.30
March	2.40		March	1.60	1.55
April	3.05		April	2.60	2.35
May	3.70		May	4.00	3.70
June	3.95		June	4.65	5.15
July	5.15		July	6.65	7.40
August	5.00		August	4.40	4.95
September	3.35	[b] 1.60	September	4.10	4.40
October	2.30	2.45	October	1.95	1.85
November	.85	1.05	November	.45	.45
December	1.30	.95	December	.40	.45
Total for period of observations.	32.85	6.05	Total for period of observations.	31.90	33.40

[a] Estimated. [b] September 15-29 only.

DISCHARGE TABLES.

The following tables, showing measurements of the discharge of California streams, are arranged alphabetically under the names of the streams considered.

AGUILAR CREEK.

Discharge measurement of Aguilar Creek.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-ft.	
Aug. —, 1899	G. F. Wright	.12	Santa Barbara County.

ALAMEDA CREEK.

Alameda Creek, in Alameda County, Cal., flows westerly into San Francisco Bay. The stream passes through narrows at Niles, where a weir dam known as the Niles dam is situated, and below this point spreads over certain absorbent gravel beds, at the lower end of which wells supplying considerable volumes of water are located. In the crest of the Niles dam is a rectangular weir opening. The length of this weir can be adjusted by inserting flash boards or planks. When the water reaches high stages it fills the rectangular weir opening

and flows over the top of the walls of the dam on the side, so that the large flood measurements that have been computed contain considerable elements of error. The measurements of smaller volumes, however, are doubtless more accurate. The Spring Valley Water Company, of San Francisco, has a pumping station which is supplied from an intake above the Niles dam, so that the amount of water pumped, as given in the following tables, should be added to the amount of water passing over the weir, in order to get total discharge.

During a term of years the Spring Valley Water Company kept observations at this weir dam of the height of water on the weir and the length of weir, and also of the amount of water pumped. These data were presented as Exhibit 11 in a certain suit entitled "Clough *v.* Crystal Springs Water Company of San Francisco," involving water rights to Alameda Creek, tried in the Alameda County superior court in the fall of 1901.

The record is not entirely complete, but the available data were assembled and computations of discharge were made by this office, and average monthly flow is given in the following tables. In some instances uncertainty exists as to the proper length of weir. This matter has been taken up, however, with the Spring Valley Water Company, and all corrections have been made for which the data are available. While the record is not considered perfect, it is the best obtainable, and in view of the extent of the data it is deemed to be worthy of publication.

Discharge measurements of Alameda Creek, Alameda County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-ft.	
Dec. 18, 1896	W. W. Brier	38.68	Niles dam.
Dec. 19, 1896	do	32.49	Do.
Dec. 20, 1896	do	30.94	Do.
Jan. 11, 1897	do	63.44	Do.
Jan. 12, 1897	do	57.25	Do.
Jan. 18, 1897	do	51.06	Do.
Dec. 18, 1896	do	7.74	3 miles below Niles.
Dec. 19, 1896	do	6.19	Do.
Dec. 20, 1896	do	.77	Do.
Jan. 11, 1897	do	44.87	Do.
Jan. 12, 1897	do	40.23	Do.
Jan. 18, 1897	do	34.04	Do.

Estimated monthly discharge of Alameda Creek at Niles dam.

Month.	Discharge over weir.			Quantity of water pumped.
	Maximum.	Minimum.	Mean.	
1889.	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Sec.-feet.*
January				12
February				11
March				8
April				13
May				13
June				12
July				11
August				7
September				5
October				7
November				8
December	2,577		996	4
The year				9.25
1890.				
January	7,792	412	1,664	2
February	2,813	237	1,007	
March	1,353	324	646	
April	412	176	242	
May	253	82	144	
June	88	41	62	
July	47	22	31	7
August	22	16	20	13
September	38	16	17	12
October	28	16	17	12
November	22	16	19	12
December	293	31	49	10
The year			326.5	5.7

Estimated monthly discharge of Alameda Creek at Niles dam—Continued.

Month.	Discharge over weir.			Quantity of water pumped.
	Maximum.	Minimum.	Mean.	
1891.	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Sec.-feet.*
January	165	38	58	9
February	3,311	38	457	10
March	3,965	98	424	5
April	253	84	147	10
May	79	47	60	12
June	47	22	32	12
July	19	2	9	12
August	2	0	2	12
September				10
October				10
November				10
December	1,701	0	84	10
The year			[a]159.1	10.17
1892.				
January	324	22	78	8
February	279	47	86	12
March	2,016	54	190	11
April	752	62	168	9
May	324	41	111	11
June	34	14	23	12
July	14	0	[b]4	12
August				9
September				6
October				6
November	3,566	599	[c]4,332	7
December	4,951	120	997	3
The year				8.8

[a] Eight months' mean.
[b] Mean of July 1 to 19, inclusive.
[c] Mean of November 28 to 30, inclusive.

Estimated monthly discharge of Alameda Creek at Niles dam—Continued.

Month.	Discharge over weir.			Quantity of water pumped.
	Maximum.	Minimum.	Mean.	
1893.	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Sec.-feet.*
January	2,016	120	437	6
February [a]	2,577	237	743	0
March				
April				
May				
June				2
July				12
August				12
September				9
October				[illegible]
November				[illegible]
December				7
The year			[b] 590	5,3[illegible]
1894.				
January				3
February				
March				1
April				[illegible]
May				[illegible]
June				[illegible]
July				[illegible]
August				[illegible]
September				[illegible]
October				[illegible]
November				2
December 9 to 31	[c] 3,700	79	659	
The year				5,[illegible]

[a] No record for rest of year. [b] Two months mean. [c] No record prior to December 9.

Estimated monthly discharge of Alameda Creek at Niles dam—Continued.

Month.	Discharge over weir.			Quantity of water pumped.
	Maximum.	Minimum.	Mean.	
1895.	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Sec.-feet.*
January	4,521	200	1,221	.....
February	[a] 2,577	206	625	.....
March	224	125	170	.....
April	176	71	124	.....
May	224	54	92	.....
June	58	16	30	.....
July	16	3	10	[b] 4
August	3	1	1	12
September	[c] 2	2	2	12
October	47	0	8	12
November	14	3	7	12
December	25	6	9	12
The year	.....	.....	191.6	[d] 10.7
1896.				
January	2,936	6	534	6
February	306	75	118	.....
March	200	79	121	.....
April	2,577	79	336	.....
May	224	54	137	.....
June	54	16	29	7
July	16	2	5	12
August	2	1	1	12
September	4	1	1	12
October	23	0	3	12
November	25	4	8	10
December	872	12	81	8
The year	.....	.....	115	6.6

[a] Record missing February 15 to 28, inclusive.
[b] No record previous to July.
[c] Record missing September 16 to 30, inclusive.
[d] Six months mean.

Estimated monthly discharge of Alameda Creek at Niles dam—Continued.

Month.	Discharge over weir.			Quantity of water pumped.
	Maximum.	Minimum.	Mean.	
1897.	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Sec.-feet.*
January	565	47	123	.....
February	2,577	224	837	.....
March	3,700	246	816	.....
April	639	98	227	.....
May	98	58	71	.....
June	54	19	25	.....
July	[a] 19	12	16	.....
August	.....	.....	.....	8
September	.....	.....	.....	8
October	.....	.....	.....	8
November	[b] 14	4	7	8
December	(c)	.....	.....	2
The year	.....	.....	.....	2.
1898.				
January	.....	.....	.....	.....
February	.....	.....	.....	[illegible]
March	.....	.....	.....	9
April	.....	.....	.....	12
May	[d] 4	2	2	12
June	[e] 4	0	0	12
July	.....	.....	.....	9
August	.....	.....	.....	[illegible]
September	.....	.....	.....	[illegible]
October	(f)	.....	.....	10
November	0	0	0	11
December	2	0	0	1[illegible]
The year	.....	.....	.....	9.1

[a] Mean of July 1 to 15, inclusive. No record for remainder of month.
[b] No record from July 16 to November 15, inclusive.
[c] No record from December 1, 1897, to May 22, 1898, inclusive.
[d] No record from December 1, 1897, to May 22, 1898, inclusive.
[e] June 18 to October 22, inclusive, water below crest.
[f] No length of weir given from October 23 to November 18, inclusive.

Estimated monthly discharge of Alameda Creek at Niles dam—Continued.

Month.	Discharge over weir.			Quantity of water pumped.
	Maximum.	Minimum.	Mean.	
1899.	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Sec.-feet.*
January	431	0	41	8
February	4	0	2	11
March [a]				6
April	200	21	54	10
May	19	6	12	11
June	8	2	4	12
July	1	0	1	12
August	0	0	0	12
September				11
October				10
November	[b] 338	8	47	6
December	565	14	101	7
The year				9.67
1900.				
January	3,700	41	297	5
February	47	25	34	12
March	306	25	112	7
April	71	25	35	12
May	31	7	17	12
June	[c] 6	1	4	12
July	1	0	0	12
August	1	0	0	12
September	[d] 17	0	4	10
October				12
November				[d] 9
December				
The year				[e] 10.45

[a] Record incomplete.
[b] August 17 to November 15, inclusive, water below crest.
[c] No record from June 17 to 24, inclusive.
[d] End of record.
[e] Eleven months mean.

ALDER CREEK.

Alder Creek is a tributary of the Santa Ana, in San Bernardino County. (See Santa Ana River, Alder Creek.)

ALISO CREEK.

Aliso Creek rises in the Fernando hills. It is normally dry at the points of measurement. During the night preceding the measurements there had been 0.65 inch of rain. At the point of first measurement it is 1.5 miles from the foothills. The measurements show the manner in which the creek sinks. Just below the point of second measurement the water all disappears.

Discharge measurements of Aliso Creek, San Fernando Valley.

Date.	Hydrographer.	Discharge.	Locality.
1901.		*Sec.-foot.*	
January 28	J. B. Lippincott	0.60	At Chatsworth road crossing.
Do	do	.32	2 miles below road crossing.

AMERICAN RIVER.

Discharge measurements of American River, Sacramento County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Sept. —, 1898	J. B. Lippincott	34.5	Folsom.
Aug. 3, 1901	C. W. Landis	619	Do.
Sept. 18, 1901	J. B. Lippincott	23	Eldorado flume at Riverton.
Sept. 16, 1899	S. G. Bennett	86	Main river, 1 mile above South Fork.
Sept. 14, 1900	do	235	Do.
Sept. 16, 1899	do	20	North Fork ditch, 2½ miles above Folsom.
Sept. 14, 1900	do	12	Do.
Dec. 28, 1878	State engineering department.	570	4 miles above Folsom.
July 14, 1879	do	4,000	Do.
Jan. 24, 1879	do	13,000	Sacramento, Twelfth street bridge.
Feb. 23, 1879	do	10,000	Near mouth.
May 21, 1879	do	10,000	Do.

Discharge measurements of South Fork of American River, Eldorado County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. 21, 1902	S. G. Bennett	100	Chillie Bar, 3 miles from Placerville.
		5	Big Canyon Creek at Chillie Bar.
Aug. 22, 1902	do	12	South Fork of Silver Creek, 200 feet above mouth.
Do	do	30	Main Silver Creek, 150 feet above junction of South Fork of Silver Creek.
Aug. 23, 1902	do	30	Eldorado ditch, 1 mile from Pacific post-office.
Sept. 18, 1899	S. G. Bennett	[a] 20	South Fork at iron road bridge near mouth.
Sept. 14, 1900	do	80.5	Do.
Do	do	35	South Fork, Natoma ditch.
Sept. 18, 1900	do	[a] 20	Do.
Aug. 2, 1901	do	36	South Fork, Natoma ditch near Salmon Falls.
Sept. 13, 1901	J. B. Lippincott	[b] 28	Silver Creek below mouth of Little Silver.
Sept. 14, 1901	do	[c] 40	Do.
Sept. 13, 1901	do	[c] 25	South Fork at Riverton.
Sept. 18, 1901	do	[d] 16	Do.
Aug. 22, 1902	S. G. Bennett	11	Do.
Sept. 19, 1901	J. B. Lippincott	69	South Fork at Mosquito Bridge.
Aug. 19, 1902	Chas. A. Miller	7.5	Branch of Natoma ditch, South Fork of American River.
Do	do	40	Natoma ditch.
Aug. 22, 1902	do	29	Natoma ditch near Salmon Falls.
Do	do	7.9	Nigger Hill ditch near Salmon Falls.
Aug. 21, 1902	do	87	Iron bridge near mouth.
Aug. 23, 1902	do	102	2 miles above iron bridge.

[a] Estimated.
[b] 4.30 p. m.
[c] 8 a. m.
[d] 11 a. m. Flume company is said to be diverting entire river at their intake above Riverton, but considerable water returns to the river from leaks in old flume.

Discharge measurements of North Fork of American River.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-ft.	
Aug. 25, 1902	S. G. Bennett	59	200 feet above Colfax, Iowa Hill road bridge.
Do	do	35	South Yuba Water Company's new power canal.
Aug. 21, 1902	Chas. A. Miller	204	Above junction with South Fork.
Aug. 23, 1902	do	145	1 mile above mouth of South Fork.
Aug. 27, 1902	do	121	Do.
Aug. 28, 1902	do	78	2¼ miles from Auburn above mouth Middle Fork.
Aug. 26, 1902	do	14	North Fork Canal, second crossing of ditch from Folsom.

Discharge measurements of Middle Fork of American River.

Date.	Hydrographer	Discharge.	Locality.
		Sec.-ft.	
Aug. 26, 1902	S. G. Bennett	25	North Fork of Middle Fork, 300 feet above junction.
Do	do	11	North Fork of Middle Fork, mining ditch.
Do	do	18	300 feet above junction with Rubicon River.
Do	do	42	Rubicon River, 300 feet above junction with Middle Fork of American River.
Aug. 28, 1902	do	110	Middle Fork above mouth.

ARMAS CREEK.

Discharge measurements of Armas Creek, Santa Barbara County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-ft.	
Aug. —, 1889	G. F. Wright	0.08	

ARMITAS CREEK.

Discharge measurements of Armitas Creek, Santa Barbara County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-ft.	
Aug. —, 1889	G. F. Wright	0.04	

ARROYO BURRO.

Discharge measurements of Arroyo Burro,[a] Santa Barbara County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. —, 1889	G. F. Wright	0.23	
June 21, 1902	J. B. Lippincott	.0036	100 feet below Moore's north line.
June 17, 1900	J. Harrington	.03	San Roqui Creek, above tunnel.
Do	do	.03	San Roqui Creek, below tunnel.
May 2, 1900	do	.04	San Roqui Creek, station 6, opposite tunnel.
Do	do	.02	San Roqui Creek, station 8, opposite tunnel.
Do	do	.08	Tunnel of Pacific Improvement Co.
June 21, 1902	J. B. Lippincott	.009	San Roqui Creek, below tunnel.
Do	do	.25	Tunnel of Pacific Improvement Co.
Do	do	.011	San Roqui Creek at station 44, opposite tunnel.
Do	do	.0063	San Roqui Creek at station 65, opposite tunnel.

ARROYO CARNERO.

Discharge measurements of Arroyo Carnero, Santa Barbara County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. —, 1889	G. F. Wright	0.08	

ARROYO GRANDE.

Discharge measurements of Arroyo Grande, San Luis Obispo County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Nov. 20, 1897	W. W. Brier	7.80	Arroyo Grande.

ARROYO LEON.

Discharge measurements of Arroyo Leon, San Mateo County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Oct. 17, 1893	W. W. Brier	0.63	¼ mile above Half Moon Bar.

[a] The upper mountainous portion of this stream is called the San Roqui and the lower part the Arroyo Burro.

ARROYO SECO.

This stream is a tributary of Los Angeles River, which it joins at the city of Los Angeles. Its basin is small, draining 21 square miles of the Sierra Madre. The river issues from the mountains on the west side of Pasadena Mesa, passes through an opening in a granite spur known as Devils Gate, and joins Los Angeles River at Los Angeles. Between the point where the water issues from the mountain and Devils Gate lies a broad river bottom 2 miles in length, composed of coarse material. In passing over this the water sinks rapidly, diminishing in volume of flood water from the mouth of the canyon to Devils Gate. It is believed that a large portion of the underflow from the gravels above Devils Gate passes to the east of Devils Gate and flows toward the San Gabriel Valley. (See also Pasadena Mesa.)

Discharge measurements of Arroyo Seco, at cable station terminal quarries, Los Angeles County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Nov. 21, 1900, 1.30 p. m	E. P. Dewey	81
Nov. 21, 1900, 2 p. m	do	100
Nov. 21, 1900, 3 p. m	do	144
Nov. 22, 1900, 11 a. m	do	85
Nov. 22, 1900, 2 p. m	do	99
Nov. 23, 1900	do	31
Nov. 24, 1900, 3 p. m	do	11.5
Nov. 26, 1900, 3.45 p. m	do	8.7
Dec. 1, 1900	W. B. Clapp	4.3
Dec. 6, 1900	do	1.4
Jan. 6, 1901	do	7
Jan. 7, 1901, 9.30 a. m	do	172
Jan. 7, 1901, 3.45 p. m	do	103
Jan. 8, 1901	do	28
Jan. 11, 1901	do	14
Jan. 14, 1901	do	7
Jan. 20, 1901	do	5
Jan. 21, 1901	do	11
Jan. 23, 1901	do	7
Jan. 28, 1901	do	32
Jan. 29, 1901	do	11
Feb. 1, 1899	W. B. Clapp	.24
Mar. 17, 1899	do	3.24
Mar. 18, 1899	do	1.77
Mar. 19, 1899	do	.98
Mar. 20, 1899	do	2.52

Discharge measurements of Arroyo Seco, etc.—Continued.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Mar. 21, 1899	W. B. Clapp	1.90
Mar. 22, 1899	do	1.64
Mar. 23, 1899	do	1.56
Mar. 26, 1899	do	2.20
Mar. 28, 1899	do	1.22
Apr. 2, 1899	do	.28
Apr. 12, 1899	do	.08
Jan. 10, 1899	E. P. Dewey	3.02
Jan. 11, 1899	do	1.90
Jan. 12, 1899	do	2
Do	do	2.06
Nov. 20, 1900	do	.23
Nov. 21, 1900, 11 a. m	do	32
Nov. 21, 1900, 12 m	do	35
Nov. 21, 1900 1 p. m	do	75
Feb. 4, 1901	W. B. Clapp	29
Feb. 5, 1901, 11 a. m	do	869
Feb. 5, 1901, 3 p. m	do	410
Feb. 6, 1901	do	200
Feb. 9, 1901	do	102
Feb. 11, 1901	do	102
Mar. 16, 1901	do	17
Apr. 29, 1901	do	1.6
May 10, 1901	do	5.3

Discharge measurements of Arroyo Seco near Devils Gate, Los Angeles County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
June 14, 1899	T. D. Allen	[a]5.17
July 12, 1897	do	[a]5.12
Aug. 9, 1897	do	[a]4.63
Oct. 11, 1897	do	[a]4.13
Nov. 8, 1897	do	[a]4.10
May 31, 1899	do	[a]3.17
July 10, 1899	W. B. Clapp	[a]2.87
Sept. 17, 1900	do	[a]3.55
Sept. 16, 1898	F. H. Olmsted	[a]3.60
Oct. 12, 1898	J. B. Lippincott	[a]3.44

[a] Devils Gate developments, including Richardson and Wilson tunnels.

Discharge measurements of Arroyo Seco, Los Angeles County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-ft.	
Jan. 11, 1899	W. B. Clapp	4.17	Loughery dam site.
Oct. 13, 1898	J. B. Lippincott	.08	Painter pipe-line diversion.
Sept. 16, 1898	F. H. Olmsted	1.69	Sheep corral, total.
Oct. 24, 1898	J. B. Lippincott	1.48	Do.
May 29, 1899	W. B. Clapp	1.43	Do.
June 3, 1899	do	1.36	Do.
June 21, 1899	do	1.62	Do.
July 1, 1899	do	1.33	Do.
July 13, 1899	do	1.30	Do.
Sept. 19, 1900	W. W. Cockins, jr	1.94	Do.
Sept. 21, 1900	J. B. Lippincott	1.37	Do.
Feb. 6, 1901	S. G. Bennett	270	Avenue 26 bridge (flood measurement).

BEAR CREEK.

See Santa Ana, Bear Creek.

BEAMS DITCH.

See San Bernardino Valley, Beams ditch.

BEAR RIVER.

Discharge measurements of Bear River, Yuba County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-ft.	
Sept. 17, 1900	S. G. Bennett	11.7	Wagon bridge 1 mile south of Wheatland.
Dec. 16, 1878	State engineering department.	10	Wire bridge.
Sept. 6, 1879	do	15	Do.
Feb. 22, 1879	do	6,500	Do.
Sept. 6, 1879	do	15	Wheatland.
Oct. 20, 1879	do	12	1 mile below wire bridge.
Aug. 25, 1902	S. G. Bennett	16	Below waste from old mining ditch.
Do	do	33	Old mining ditch of South Yuba Water Company, one-fourth mile below head works.
Aug. 26, 1902	Charles A. Miller	28	Wooden flume of South Yuba Water Company, near Auburn.

Estimated monthly discharge of Bear River, Merced County, at base of foothills.[a]

[Drainage area, 166 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1878.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
November	0	0	0	0	0	0
December	0	0	0	0	0	0
1879.						
January	0	0	0	0	0	0
February	312	0	25	1,388	0.15	0.16
March	570	0	57	3,505	.34	.39
April	197	5	54	3,213	.33	.37
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	257	0	18	1,107	.11	.13
The year	570	0	13	9,213	.08	1.35
1880.						
January	217	0	25	1,537	.15	.17
February	700	0	61	3,509	.37	.40
March	85	10	31	1,906	.19	.22
April	2,080	25	321	19,101	1.93	2.15
May	47	0	23	1,414	.14	.16
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	421	0	115	7,071	.69	.80
The year	2,080	0	48	34,538	.29	3.90

[a] Authority, State engineering department.

Estimated monthly discharge of Bear River, etc.—Continued.

Month.	Discharge			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1881.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	1,920	20	169	10,391	1.02	1.18
February	1,423	47	214	11,885	1.29	1.34
March	197	13	48	2,951	.29	.33
April	20	0	6	357	.04	.04
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
The year	1,920	0	36	25,584	.23	2.89
1882.[a]						
January	0	0	0	0	0	0
February			33	1,833	.20	.21
March			100	6,149	.60	.69
April			130	7,736	.78	.87
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October			17	1,045	.10	.12
November			25	1,488	.15	.17
December			17	1,045	.10	.12
The year			27	19,296	.16	2.18

[a] Run-off for 1882, 1883, and 1884, estimated from previous measurements or from run off of neighboring streams.

Estimated monthly discharge of Bear River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1883.[a]	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January			66	4,058	.40	.46
February			33	1,833	.20	.21
March			170	10,453	1.02	1.18
April			100	5,950	.60	.67
May			50	3,074	.30	.35
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
The year			35	25,368	.21	2.87
1884.[a]						
January			17	1,045	.10	.12
February			660	37,964	3.98	4.29
March			910	55,954	5.48	6.32
April			660	39,273	3.98	4.44
May			330	20,291	1.99	2.29
June			170	10,116	1.02	1.14
July			66	4,058	.40	.46
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0

[a] Run-off for 1882, 1883, and 1884, estimated from previous measurements or from run-off of neighboring streams.

BIG ROCK CREEK.

Discharge measurements of Big Rock Creek, Los Angeles County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec. feet.	
Jan. 4, 1898	J. B. Lippincott	5.27	Dam site above development tunnel.
Jan. 4, 1898	do	1.27	Diversion to tunnel.
Jan. 4, 1898	do	1.33	Developed in tunnel.
Jan. 4, 1898	do	.78	Cienega on Pallett tributary.

WILLIAMS RIVER.

Discharge measurement of Williams River, Yuma County, Ariz.

Date.	Hydrographer.	Discharge.	Locality.
		Sec. feet.	
Jan. 1, 1902	J. B. Lippincott	4	Mouth of river.
Oct. 28, 1902	E. T. Perkins	4	Do.

BLOOMINGTON FLUME, SAN BERNARDINO COUNTY.

See San Bernardino Valley.

BRISCOE CREEK, GLENN COUNTY.

See Stony Creek, Briscoe tributary.

BURNEY CREEK.

See Pit River, Burney tributary.

BUTANO CREEK.

Discharge measurement of Butano Creek, San Mateo County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec. feet.	
Oct. 17, 1893	W. W. Brier	2.05	5 miles above junction with Pescadero Creek.

CACHE CREEK.[a]

This stream is the outlet of Clear Lake, in Lake County, Cal., and is described in Water-Supply Paper No. 51, p. 453.

On account of the great importance of Clear Lake as a storage reservoir, a gaging station was established at the wagon bridge across Cache Creek, one-half mile north of the town of Lower Lake, January 1, 1901. Gage rods were put in at this point and an observer was employed by Mr. P. N. Ashley, of Woodlands, for the Agricultural Department, about October, 1900, but no meter measurements were made.

In order to determine the evaporation from the surface of Clear Lake an evaporation pan and gage were placed in a cove near Lakeport in January, 1901, and the observations for evaporation were begun February 1 by Capt. D. C. Rumsey. The pan is not exposed to the full force of the wind, as the waves often run high.

Discharge measurements of Cache Creek, Lake County.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
		Feet.	*Sec.-feet.*	
Sept. 24, 1900	S. G. Bennett		3.8	Lower Lake Bridge.
Dec. 16, 1900	do	1.18	123	Do.
Jan. 25, 1901	do	3.60	675	Do.
Apr. 13, 1901	do	3.80	673	Do.
June 17, 1901	S. Matthews	2.85	333	Do.
July 15, 1901	do	2.45	236	Do.
Aug. 13, 1901	do	2.05	144	Do.
Sept. 4, 1901	J. R. Anderson	1.72	88	Do.
Oct. 5, 1901	do	1.45	34	Do.
Nov. 9, 1901	do	1.20	20	Do.
Nov. 29, 1901	do	1.60	69	Do.
Dec. 30, 1901	do	1.60	65	Do.
Jan. 29, 1902	do	1.60	70	Do.
Feb. 13, 1902	do	2.50	260	Do.
Mar. 3, 1902	do	6.50	1,151	Do.
Mar. 19, 1902	do	7.70	1,866	Do.
Apr. 5, 1902	do	6.5	1,397	Do.
Apr. 24, 1902	do	5.9	1,212	Do.
May 3, 1902	do	5.2	1,042	Do.
May 19, 1902	do	4.5	853	Do.
May 31, 1902	do	4.0	720	Do.
June 14, 1902	do	3.6	629	Do.
July 12, 1902	do	3.1	422	Do.

[a] For a detailed statement concerning the hydrography of Cache Creek, see Water-Supply Paper No. 45, by A. E. Chandler.

Discharge measurements of Cache Creek, Lake County—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
		Feet.	*Sec.-feet.*	
July 26, 1902	J. R. Anderson	2.8	345	Lower Lake Bridge.
Aug. 9, 1902	do	2.7	289	Do.
Aug. 22, 1902	do	2.5	246	Do.
Sept. 6, 1902	do	2.3	193	Do.
Sept. 20, 1902	do	2.2	156	Do.
Oct. 4, 1902	do	2.1	108	Do.
Oct. 20, 1902	do	2.0	83	Do.
Nov. 4, 1902	do	2.1	118	Do.
Nov. 19, 1902	do	2.8	245	Do.
Dec. 19, 1902	S. G. Bennett	2.8	300	Do.
June 24, 1900	do		196	Rumsey, Colusa County.
June 25, 1900	do		189	Do.
Sept. 23, 1900	do		3.8	Do.
Apr. 12, 1901	do		811	Do.
Apr. 15, 1901	do	3.4	720	Woodland Bridge, Yolo County.
May 8, 1902	do	4.4	1,276	Do.
Sept. 25, 1902	do	1.4	56	Do.

Estimated monthly discharge of Cache Creek at Lower Lake.

[Drainage area, 500 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	2,020	155	535	32,896	1.07	1.23
February	2,520	615	909	50,483	1.82	1.89
March	1,330	805	1,079	66,345	2.16	2.49
April	805	530	654	38,916	1.31	1.46
May	570	380	481	29,576	.96	1.10
June	415	255	327	19,458	.65	.73
July	255	155	199	12,236	.40	.46
August	155	86	114	7,010	.23	.26
September	86	40	55	3,273	.11	.12
October	50	16	31	1,906	.06	.07
November	62	16	26	1,547	.05	.06
December	74	40	62	3,812	.12	.14
The year	2,520	16	373	263,858	.75	10.00

Estimated monthly discharge of Cache Creek at Lower Lake—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1902.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	78	40	53	3,259	0.11	0.13
February	1,345	52	381	21,160	.76	.79
March	2,080	1,275	1,766	108,587	3.53	4.07
April	1,660	1,100	1,427	84,912	2.85	3.18
May	1,100	670	865	53,187	1.73	1.99
June	670	460	556	33,084	1.11	1.24
July	460	310	380	23,365	.76	.88
August	310	200	243	14,941	.49	.56
September	200	130	163	9,699	.33	.37
October	150	110	127	7,809	.25	.29
November	580	110	263	15,650	.53	.59
December	340	280	307	18,877	.61	.70
The year	2,080	40	544	394,530	1.09	14.79

CAJON CREEK.

Discharge measurements of Cajon Creek, San Bernardino County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
June 8, 1900	S. G. Bennett	1.37	Keenebrook station.

CALAVERAS RIVER.

Discharge measurements of Calaveras River, Calaveras County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Sept. 6, 1899	S. G. Bennett	Dry	San Andreas, Jackson road.

Estimated monthly discharge of Calaveras River at Bellota.[a]

[Drainage area, 491 square miles.]

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1878.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
November[b]	0	0	0	0
December[b]	0	0	0	0
1879.				
January	229	14,081	0.47	0.54
February	648	35,988	1.32	1.37
March	1,068	65,669	2.18	2.51
April	680	40,463	1.38	1.54
May	166	9,878	.34	.39
June[b]	98	5,831	.20	.22
July[b]	24	1,476	.05	.06
August[b]	0	0	0	0
September[b]	0	0	0	0
October[b]	0	0	0	0
November[b]	0	0	0	0
December[b]	295	18,139	.60	.69
The year[b]	267	191,525	.55	7.32
1880.[c]				
January	221	13,589	.45	.52
February	393	22,606	.80	.86
March	614	37,753	1.25	1.44
April	4,174	248,370	8.50	9.48
May	1,473	90,571	3.00	3.46
June	196	11,663	.40	.47
July	24	1,476	.05	.06
August	10	615	.02	.02
September	0	0	0	0
October	0	0	0	0
November	0	0	0	0
December	246	15,126	.50	.58
The year	613	441,769	1.25	16.87

[a] Authority, California State engineering department.

[b] For November and December, 1878, and from June, 1879, to October, 1884, estimated from run off of neighboring stream.

[c] Estimated from run-off of neighboring stream.

Estimated monthly discharge of Calaveras River at Bellota—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1881.[a]	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	1,478	90,571	3.00	3.46
February	2,700	149,950	5.50	5.78
March	982	60,381	2.00	2.31
April	982	58,433	2.00	2.23
May	196	12,052	.40	.46
June	74	4,403	.15	.17
July	49	3,013	.10	.12
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	0	0	0	0
December	74	4,550	.15	.17
The year	544	383,353	1.11	14.65
1882.[a]				
January	344	21,152	.70	.81
February	442	24,547	.90	.94
March	1,719	105,697	3.50	4.04
April	1,719	102,288	3.50	3.90
May	2,946	181,142	6.00	6.92
June	246	14,638	.50	.56
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	98	6,026	.20	.23
November	147	8,747	.30	.33
December	147	9,039	.30	.35
The year	651	473,276	1.33	18.08

[a] Estimated from run-off of neighboring stream.

Estimated monthly discharge of Calaveras River at Bellota—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1883.[a]	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	491	30,190	1.00	1.15
February	393	21,826	.80	.83
March	737	45,316	1.50	1.73
April	982	58,433	2.00	2.23
May	491	30,190	1.00	1.15
June	196	11,663	.40	.45
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	74	4,550	.15	.17
November	24	1,428	.05	.06
December	49	3,013	.10	.12
The year	286	206,609	.58	7.89
1884.[a]				
January	196	12,052	.40	.46
February	2,455	141,213	5.00	5.39
March	2,946	181,142	6.00	6.92
April	2,455	146,083	5.00	5.58
May	491	30,190	1.00	1.15
June	491	29,217	1.00	1.12
July	196	12,052	.40	.46
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0

[a] Estimated from run-off of neighboring stream.

CALIENTE CREEK.[a]

Discharge measurements of Caliente Creek, Kern County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
May 1, 1895	J. B. Lippincott	23	1¼ miles northwest of station.

[a] Stream usually dry in summer months.

Estimated monthly discharge of Caliente Creek, Kern County, at base of foothills.[a]

[Drainage area, 423 square miles.]

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1878.	*Second-feet.*	*Acre-feet.*	*Second-feet.*	*Inches.*
November	0	0	0	0
December	0	0	0	0
1879.				
January	34	2,091	0.08	0.09
February	59	3,277	.14	.15
March	30	1,845	.07	.08
April	106	6,307	.25	.28
May	76	4,673	.18	.21
June	25	1,488	.06	.07
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	110	6,545	.26	.29
December	212	13,035	.50	.58
The year	54	39,261	.13	1.75
1880.				
January	508	31,236	1.20	1.38
February	973	55,968	2.30	2.48
March	1,100	67,636	2.60	3.00
April	1,227	73,012	2.90	3.24
May	846	52,019	2.00	2.31
June	212	12,615	.50	.56
July	21	1,291	.05	.06
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	85	5,058	.20	.22
December	212	13,035	.50	.58
The year	432	311,870	1.02	13.83

[a] Estimated from run-off of neighboring streams. Authority, California State engineering department.

Estimated monthly discharge of Caliente Creek, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1881.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
January	212	13,035	0.50	0.58
February	423	23,492	1.00	1.04
March	423	26,009	1.00	1.15
April	423	25,170	1.00	1.12
May	423	26,009	1.00	1.15
June	212	12,615	.50	.56
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	0	0	0	0
December	51	3,136	.12	.14
The year	181	129,466	.43	5.74
1882.				
January	51	3,136	.12	.14
February	63	3,499	.15	.16
March	212	13,035	.50	.58
April	212	12,615	.50	.56
May	42	2,582	.10	.12
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	63	3,749	.15	.17
December	63	3,874	.15	.17
The year	59	42,490	.14	1.90

Estimated monthly discharge of Caliente Creek, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1883.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	63	3,874	0.15	0.17
February	63	3,499	.15	.16
March	338	20,783	.80	.92
April	212	12,615	.50	.56
May	169	10,391	.40	.46
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	42	2,582	.10	.12
November	42	2,499	.10	.11
December	63	3,874	.15	.17
The year	83	60,117	.20	2.67
1884.				
January	212	13,035	.50	.58
February	1,269	72,994	3.00	3.24
March	1,269	78,028	3.00	3.46
April	846	50,340	2.00	2.23
May	169	10,391	.40	.46
June	212	12,615	.50	.56
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0

CALLOWAY CANAL.

See Kern River, Calloway canal.

CAMP CARLTON DITCH, SAN BERNARDINO COUNTY.

See San Bernardino Valley, Camp Carlton ditch.

CANYADA DEL CORRAL.

Discharge measurement of Canyada del Corral Creek.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. —, 1889	G. F. Wright	0.15	Santa Barbara County.

CANYADA LARES.

Discharge measurement of Canyada Lares Creek.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. —, 1889	G. F. Wright	0.08	Santa Barbara County.

CANYADA REFUGIO.

Discharge measurement of Canyada Refugio Creek.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. —, 1889	G. F. Wright	0.31	Santa Barbara County.

CANYADA VERDE.

Discharge measurement of Canyada Verde Creek.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. —, 1889	G. F. Wright	0.08	Santa Barbara County.

CAPITAN CREEK.

Discharge measurement of Capitan (El) Creek.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. —, 1889	G. F. Wright	0.23	Santa Barbara County.

CARPENTERIA CREEK.

Discharge measurement of Carpenteria Creek.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. —, 1889	G. F. Wright	0.08	Santa Barbara County, 1 mile above Placitas Road.
June 16, 1900	R. Moyer	.003	Do.

CARSON RIVER.

EAST FORK CARSON RIVER.

This branch of Carson River has its source in the high Sierra of California, and flows northward, crossing the Nevada-California boundary line and entering Carson Valley at Rodenbah's ranch, about 20 miles from Carson, a little east of south. There it turns to the northwest, and a short distance above the town of Genoa unites with the West Fork, forming Carson River. The drainage area above Rodenbah's is 414 square miles in extent, and is mapped on the Markleeville and Dardanelles atlas sheets of the United States Geological Survey. This gaging station was established by L. H. Taylor on October 17, 1900, at the place where measurements were made in the years 1890, 1891, and 1892. The rod was an inclined timber securely fastened to posts set in the right bank of the stream. The bench mark was on a basalt rock at the edge of the stream, 20 feet from the gage, and was at an elevation of 6.3 feet above gage datum. The channel at the station is straight and the banks are high. The stream bed is of cobbles and gravel, and is quite stable. Measurements are made from a cable and suspended car. On August 2, 1901, a loose rock dam was raised a short distance below the gaging station, which affected the velocity at the latter point. The dam was partly washed out by a freshet on December 4, 1901. On March 10, 1901, a new gage was established a short distance downstream from the original one, which had been destroyed. It consists of a vertical timber driven into the stream bed at the right bank and spiked to a cottonwood tree. A bench mark was also established on a large granite bowlder 20 feet south of the gage, under the cable from which the measurements are made. Its elevation is 8.10 feet above the datum of the gage.

Discharge measurements of East Fork Carson River, near Gardnerville, Nev.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Sec.-ft.*
Mar. 10, 1901	L. H. Taylor	4.00	459
Apr. 30, 1901	do	4.55	a864
June 4, 1901	do	5.85	1,868
June 9, 1901	do	5.40	1,356
Sept. 29, 1901	do	3.70	a127
Nov. 7, 1901	do	3.70	a117
Dec. 19, 1901	do	3.40	136

a Approximate.

Estimated monthly discharge of East Fork Carson River, at Gardnerville (Rodenbah), Nev.

[Drainage area, 1,519 square miles.]

Month.	Mean discharge.	Month.	Mean discharge.
1890.	*Sec.-ft.*	1891—Continued.	*Sec.-ft.*
April	1,026	October	385
May	2,654	November	385
June	2,430	December	438
July	1,789		
August	597	The year	619
September	415	1892.	
October	386	January	380
November	384	February	380
December	379	March	422
1891.		April	478
January	388	May	1,226
February	402	June	1,158
March	783	July	506
April	452	August	413
May	1,445	September	414
June	1,328	October	416
July	618	November	414
August	408	December	1,097
September	388	The year	670

For further details of the flow of East and West forks of Carson River, see the Twelfth Annual Report of the United States Geological Survey, Pt. II, page 351.

WEST FORK, CARSON RIVER.

This stream rises on the eastern slope of the Sierra Nevada in California, immediately southeast of the source of Truckee River, and, flowing in a general northeast direction, crosses the State line into Nevada and joins the East Fork near Genoa, in Carson Valley. The drainage area is mapped on the Markleeville atlas sheet of the United States Geological Survey. This gaging station, established by L. H. Taylor on October 18, 1900, is about three-fourths of a mile above the post-office at Woodfords, near the point where measurements were made in 1890, 1891, and 1892. The gage at present in use is a vertical timber, but it is only temporary, the equipment of the station being incomplete. The channel at the station is straight, the banks are high and rocky, and the bed is of rock and gravel and not likely to shift. Measurements are made from a car suspended on a steel cable across the stream.

Discharge measurements of West Fork, Carson River, near Woodfords, Cal.

Date.	Hydrographer	Gage height.	Discharge.
		Feet.	*Sec.-feet.*
Mar. 8, 1901	L. H. Taylor	3.30	1.58
Apr. 28, 1901	do	3.95	[a]3.21
May 26, 1901	do	3.80	2.85
May 31, 1901	do	4.05	[a]3.50
June 13, 1901	do	3.75	2.74
Sept. 21, 1901	do	2.35	.31
Nov. 6, 1901	do	2.60	.68
Apr. 22, 1902	D. W. Hayes		182.50
May 13, 1902	C. V. Taylor		422.50
July 3, 1902	D. W. Hayes		157.60
July 30, 1902	do		46.70
Aug. 6, 1902	C. V. Taylor		53.00
Sept. 9, 1902	L. L. Richards		40.00

[a]Approximate.

Estimated monthly discharge of West Fork Carson River, at Woodfords, Cal.

[Drainage area, 70 square miles.]

Month.	Mean discharge.	Month.	Mean discharge.
1890.	*Sec.-ft.*	1891—Continued.	*Sec.-ft.*
April	284	May	534
May	657	June	33[illegible]
June	614	July	130
July	380	August	65
August	135	September	41
September	75	October	48
October	67	November	43
November	49	December	47
December	53	The year	12[illegible]
1891.		1892.	
January	52	January	45
February	48	February	46
March	61	March	65
April	127		

Discharge measurements in Carson River Basin.

Date.	Hydrographer.	Discharge.	Location.
		Sec. ft.	
Aug. 6, 1902	C. V. Taylor	0.72	Indian Creek and Harvey's ditch.
Do	do	1.18	Hawkins Creek, one-fourth mile above Hawkins's house.
Sept. 9, 1902	L. L. Richards	1.10	Do.
Aug. 6, 1902	C. V. Taylor	1.27	Petersons Creek, near old sawmill.
Sept. 9, 1902	L. L. Richards	.42	Petersons Creek, above Cohn's meadow.
Aug. 6, 1902	C. V. Taylor	2.84	Bruns Creek, mouth of canyon.
Sept. 9, 1902	L. L. Richards	3.48	Do.

CASCADE CREEK, TUOLUMNE COUNTY.

See Stanislaus River, Cascade Creek.

CHERRY CREEK, TUOLUMNE COUNTY.

See Tuolumne River, Cherry Creek.

CHINO CREEK, RIVERSIDE COUNTY.

See Santa Ana River, Chino Creek.

CHOWCHILLA CREEK.

Estimated monthly discharge of Chowchilla Creek at base of foothills.[a]

[Drainage area, 268 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1878.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
November	0	0	0	0	0	0
December	0	0	0	0	0	0
1879.						
January	140	0	8	492	0.03	0.03
February	1,000	0	56	3,110	.21	.22
March	760	0	63	3,874	.24	.28
April	300	11	48	2,856	.18	.20
May	140	0	14	861	.05	.06
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	192	0	12	738	.04	.04
The year	1,000	0	17	11,931	.06	.83
1880.						
January	18	0	5	307	.02	.02
February	1,500	0	167	9,606	.62	.67
March	91	11	19	1,168	.07	.08
April	6,380	0	1,266	75,332	4.72	5.26
May[b]	.....	.....	53	3,259	.20	.23
June[b]	.....	.....	27	1,607	.10	.11
July[b]	0	0	0	0	0	0
August[b]	0	0	0	0	0	0
September[b]	0	0	0	0	0	0
October[b]	0	0	0	0	0	0
November[b]	0	0	0	0	0	0
December[b]	.....	.....	201	12,359	.75	.86
The year	.....	.....	145	103,638	.54	7.23

[a] Authority, California State engineering department

[b] Estimated from previous measurements, or from run-off of neighboring stream

Estimated monthly discharge of Chowchilla Creek at base of foothills—Continued.

Month.	Discharge.			Total discharge.	Run-off	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1881.[a]	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January			295	18,139	1.10	1.27
February			375	20,826	1.40	1.46
March			83	5,103	.31	.36
April			11	655	.04	.04
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December			27	1,660	.10	.12
The year			66	46,383	.25	3.35
1882.						
January[a]			54	3,320	.20	.23
February	1,120	0	164	9,108	.61	.64
March	10,770	0	1,168	71,818	4.36	5.02
April[a]			268	15,947	1.00	1.12
May[a]			54	3,320	.20	.23
June[a]	0	0	0	0	0	0
July[a]	0	0	0	0	0	0
August[a]	0	0	0	0	0	0
September[a]	0	0	0	0	0	0
October[a]	0	0	0	0	0	0
November[a]			53	3,154	.20	.22
December[a]			27	1,660	.10	.12
The year			149	108,327	.56	7.58

[a] Estimated from previous measurements, or from run-off of neighboring stream.

Estimated monthly discharge of Chowchilla Creek at base of foothills—Continued.

Month.	Discharge.				Run-off.	
	Maximum.	Minimum.	Mean.	Total discharge.	Per square mile.	Depth.
1883.[a]	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January			80	4,919	0.30	0.35
February			53	2,943	.20	.21
March			268	16,479	1.00	1.15
April			134	7,974	.50	.56
May			107	6,579	.40	.46
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
The year			54	38,894	.20	2.73
1884.[a]						
January			27	1,660	.10	.12
February			1,340	77,078	5.00	5.39
March			1,608	98,872	6.00	6.92
April			1,072	63,788	4.00	4.46
May			804	49,436	3.00	3.46
June			804	47,841	3.00	3.35
July			268	16,479	1.00	1.15
August			27	1,660	.10	.12
September			0	0	0	0
October			0	0	0	0

[a] Estimated from previous measurements, or from run-off of neighboring stream.

CITY CREEK.

Discharge measurements of City Creek at mouth of canyon, San Bernardino County.

Date.	Hydrographer.	Discharge.
		Sec.-feet
June 11, 1898	J. B. Lippincott	3.46
Sept. 9, 1898	....do	.07
Mar. 25, 1899	S. G. Bennett	8.80
Aug. 25, 1899	....do	.17
July 12, 1900	....do	.16
Oct. 1, 1900	W. W. Cockins, jr	.21
Apr. 7, 1902	S. G. Bennett	12.5
Sept. 4, 1902	W. B. Clapp	.2

NOTE.- For measurements of sundry small canals from City Creek in San Bernardino Valley see Santa Ana River near Cotton. Detailed descriptions given in Water-Supply Paper No. 3[illegible]

COLD SPRING CANYON.

Discharge measurements of Cold Spring Canyon, Santa Barbara County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. 13, 1897	Montecito Water Co.	0.66	City tunnel.
Do	....do	.08	Creek at falls.
Sept. 6, 1897	....do	.31	City tunnel.
Do	....do	.06	Creek at falls.
Sept. 12, 1897	....do	.31	City tunnel.
Do	....do	.09	Creek at falls.
Oct. 2, 1897	....do	.28	City tunnel.
Do	....do	.09	Creek at falls.
Dec. 8, 1897	....do	.22	City tunnel.
Do	....do	.09	Creek at falls.
Jan. 26, 1898	....do	.22	City tunnel.
Do	....do	.11	Creek at falls.
June 14, 1900	R. Moyer	.02	City tunnel, station 29+97.
Do	....do	.04	City tunnel, 100 feet from head, station 29+27.
Apr. 19, 1898	Montecito Water Co.	.22	City tunnel.
June 10, 1900	J. B. Lippincott	.41	City tunnel at Portal.
Do	....do	Dry.	Creek at falls.
Mar. 22, 1896	Montecito Water Co.	.06	City tunnel.
Do	....do	Dry.	Creek at falls.
Aug. —, 1889	G. F. Wright	.23	

COLDWATER CREEK.

Discharge measurements of Coldwater Creek, Riverside County, one-fifth mile above dam.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Jan. 4, 1899	F. Rolfe	0.82
Jan. 18, 1899	do	1.43
Jan. 27, 1899	do	.84
Feb. 3, 1899	do	.99
Feb. 11, 1899	do	.97
Feb. 18, 1899	do	.78
Feb. 24, 1899	do	.94
Mar. 1, 1899	do	.92
Mar. 12, 1899	do	.71
Mar. 17, 1899	do	1.60
Mar. 25, 1899	do	1.18
Mar. 31, 1899	do	.84
Apr. 14, 1899	do	.68
Apr. 15, 1899	do	.62
Apr. 21, 1899	do	.26
Apr. 26, 1899	do	.38
May 5, 1899	do	.37
May 13, 1899	do	.21
May 17, 1899	do	.21
May 29, 1899	do	.27
May 31, 1899	do	.38
Do	do	.30
June 5, 1899	do	.30
June 7, 1899	do	.22

COLORADO RIVER.

Discharge measurements of Colorado River.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
		Feet.	*Sec.-feet.*	
Aug. 18, 1875	U. S. Engineers		18,410	Stones Ferry.
Aug. 20, 1875	do		11,610	Camp Mohave.
Mar. 15, 1876	do		7,659	Yuma.
Jan. 17, 1895	J. B. Lippincott	20.3	9,737	Do.
Apr. 18, 1895	do	20.2	21,094	Do.
July 10, 1895	do	21.2	45,533	Do.
May 20, 1896	do	22.2	57,903	Do.

Discharge measurements of Colorado River—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
		Feet.	*Sec.-feet.*	
Aug. 18, 1901	H. G. Heisler	20.71	18,683	Yuma.
Jan. 9, 1902	J. B. Lippincott	17.2	3,637	Do.
Feb. 20, 1902	S. G. Bennett	17.15	3,?39	Do.
May 30, 1902	do	23	38,400	Do.
July 9, 1902	do	20.52	14,799	Do.
July 7, 1902	W. W. Follett	21.06	18,350	Do.
Oct. 11, 1902	S. G. Bennett	18.5	6,030	Do.
Oct. 14, 1902	R. P. H. Laney	17.9	4,798	Do.
Oct. 17, 1902	do	17.5	3,559	Do.
Oct. 21, 1902	do	17.6	4,203	Do.
Oct. 24, 1902	do	17.5	3,547	Do.
Nov. 12, 1902	S. G. Bennett	17.4	3,614	Do.
Nov. 13, 1902	do	17.5	3,865	Do.
Nov. 15, 1902	W. D. Smith	18.55	5,276	Do.
Nov. 18, 1902	do	18.05	4,213	Do.
Nov. 20, 1902	do	18	4,368	Do.
Nov. 22, 1902	do	18.10	4,600	Do.
Nov. 24, 1902	do	18.45	5,500	Do.
Nov. 26, 1902	do	18.40	4,979	Do.
Nov. 28, 1902	do	18.50	5,544	Do.
Dec. 1, 1902	do	20	12,596	Do.
Dec. 3, 1902	do	19.25	7,862	Do.
Dec. 5, 1902	do	18.85	6,347	Do.
Dec. 8, 1902	do	18.3	4,825	Do.
Dec. 10, 1902	do	18.2	5,081	Do.
Dec. 12, 1902	do	18	4,669	Do.
Dec. 15, 1902	do	17.65	3,818	Do.
Dec. 16, 1902	do	17.5	3,589	Do.
Dec. 18, 1902	do	18.3	5,361	Do.
Dec. 19, 1902	do	18.05	4,607	Do.
Dec. 20, 1902	do	18.05	5,237	Do.
Dec. 22, 1902	do	17.7	4,698	Do.
Dec. 24, 1902	do	18	4,863	Do.
Dec. 26, 1902	do	18.1	5,356	Do.
Dec. 27, 1902	do	18.3	5,497	Do.
Dec. 29, 1902	do	18	4,588	Do.
Dec. 31, 1902	do	17.7	4,176	Do.

Estimated monthly discharge of Colorado River at Yuma.

[Drainage area, 225,049 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1902.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	4,520	3,230	3,727	229,164	0.017	0.020
February	4,720	3,300	3,955	219,650	.018	.019
March	5,340	4,340	4,903	301,474	.022	.025
April	11,400	4,340	6,179	367,676	.027	.030
May	59,200	11,400	35,961	2,211,156	.160	.184
June	56,200	29,000	42,520	2,530,115	.189	.211
July	27,000	5,130	12,527	770,255	.056	.065
August	5,560	3,230	4,183	257,203	.019	.022
September	8,360	3,050	3,819	227,246	.017	.019
October	6,600	3,140	4,299	264,335	.019	.022
November	5,540	3,140	4,187	249,144	.019	.021
December	12,600	3,590	5,412	332,771	.025	.028
The year	59,200	3,050	10,973	7,960,189	.049	.666

Discharge measurements of Colorado River at Bulls Head Canyon.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Sec.-feet.*
Dec. 5, 1902	J. T. Whistler	3	5,786
Dec. 10, 1902	L. M. Barnes	2.65	4,051
Dec. 13, 1902	do	2.45	3,222
Dec. 17, 1902	do	2.95	4,138
Dec. 20, 1902	do	3.50	4,792
Dec. 24, 1902	do	3.23	4,939
Dec. 29, 1902	do	2.45	3,366
Dec. 31, 1902	do	2.20	2,913

COLTON CITY AND COLTON TERRACE, SAN BERNARDINO COUNTY.

See San Bernardino Valley.

CONVICT CREEK.

See Owens River, Convict Creek.

COSUMNES RIVER.

Discharge measurements of Cosumnes River, Eldorado County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Sept. 16, 1899	S. G. Bennett	2	Bridge near Latrobe, Jackson road.
Do	do	2	Ditch on south side of Latrobe, Jackson road.
Sept. 12, 1900	do	1.7	Bridge near Latrobe, Jackson road.
Do	do	3.7	Ditch on south side.

Estimated monthly discharge of Cosumnes River at Live Oak Suspension Bridge, Sacramento County.[a]

[Drainage area, 580 square miles.]

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile	Depth.
1878.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
November	29	1,726	0.05	0.06
December	29	1,783	.05	.06
1879.				
January	290	17,831	.50	.58
February	1,218	67,644	2.10	2.19
March	1,740	106,988	3	3.46
April	3,132	186,367	5.40	6.03
May	3,248	199,712	5.60	6.46
June	3,480	207,074	6	6.69
July	422	25,948	.73	.84
August	116	7,133	.20	.23
September	23	1,369	.04	.04
October	17	1,045	.03	.03
November	52	3,094	.09	.10
December	406	24,964	.70	.81
The year	1,179	849,169	2.03	27.46

[a] Authority, California State engineering department. Estimated from run-off of neighboring drainage basins.

Estimated monthly discharge of Cosumnes River, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1880.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	232	14,265	0.40	0.46
February	441	25,367	.76	.82
March	696	43,795	1.20	1.38
April	4,582	272,648	7.90	8.81
May	5,104	313,833	8.80	10.15
June	6,090	362,380	10.50	11.71
July	2,726	167,615	4.70	5.42
August	348	21,398	.60	.69
September	29	1,726	.05	.06
October	17	1,045	.03	.03
November	12	714	.02	.02
December	290	17,831	.50	.58
The year	1,714	1,241,617	2.96	40.13
1881.				
January	1,624	99,856	2.80	3.23
February	3,074	170,721	5.30	5.52
March	1,102	67,759	1.90	2.19
April	3,190	189,818	5.50	6.14
May	3,074	189,013	5.30	6.11
June	1,218	72,476	2.10	2.34
July	174	10,699	.30	.35
August	87	5,349	.15	.17
September	87	5,177	.15	.17
October	58	3,566	.10	.12
November	174	10,354	.30	.33
December	522	32,097	.90	1.04
The year	1,199	856,885	2.07	27.71

Estimated monthly discharge of Cosumnes River, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off	
			Per square mile.	Depth.
1882.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	522	32,097	0.90	1.04
February	522	28,990	.90	.94
March	1,740	106,988	3	3.46
April	2,320	138,050	4	4.46
May	4,524	278,170	7.80	8.99
June	2,900	172,562	5	5.58
July	696	42,795	1.20	1.38
August	580	35,663	1	1.15
September	52	3,094	.09	.10
October	232	14,265	.40	.46
November	100	5,950	.17	.19
December	100	6,149	.17	.20
The year	1,191	864,773	2.05	27.95
1883.				
January	348	21,398	.60	.69
February	290	16,106	.50	.52
March	522	32,097	.90	1.04
April	1,740	103,537	3	3.33
May	3,480	213,977	6	6.92
June	2,320	138,050	4	4.46
July	580	35,663	1	1.15
August	232	14,265	.40	.46
September	87	5,177	.15	.17
October	87	5,349	.15	.17
November	116	6,902	.20	.22
December	116	7,133	.20	.23
The year	827	599,654	1.43	19.38

Estimated monthly discharge of Cosumnes River, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1884.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	145	8,916	0.25	0.29
February	1,740	100,086	3	3.24
March	3,480	213,977	6	6.92
April	3,480	207,074	6	6.69
May	2,900	178,314	5	5.76
June	2,320	138,050	4	4.46
July	2,320	142,651	4	4.61
August	580	35,663	1	1.15
September	116	6,902	.20	.22
October	87	5,349	.15	.17

COW CREEK, TUOLUMNE COUNTY.

See Stanislaus River, Cow Creek.

CUCAMONGA CREEK.

Discharge measurements of Cucamonga Creek, San Bernardino County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. 26, 1898	F. H. Olmsted	1.04	Headworks in canyon.
July 11, 1900	S. G. Bennett	1.08	Do.
Oct. 7, 1901	do	2.06	Do.
Apr. 3, 1902	do	4.80	Do.

Following is a table showing measurements of cienagas and developed water at Red Hill:

Tabulation of measurements of cienagas and developments at Red Hill as indicated in miners' inches.

[Fifty miners' inches to one second-foot.]

Date.	Hydrographer.	East side.								West side.										
		Creek Div. box, 30-inch line.	Div. box 1, 16-inch line and V tunnel, built in 1886-1887.	China cienega	Lone Star Spring tunnel.	V tunnel, built prior to 1886.	Ciénaga below No. 1.	Total without Lone Star.	Total.	Spring northwest of tunnel No. 2 portal.	W. cienega, "D."	Picnic Spring, cienega C.	Artesian wells Nos. 1 and 2.	Tiburcio Spring.	Tunnel No. 2 on 90-acre.	China garden.	Stowell wells and tunnel above 90-acre tract.	Rain previous season.	Total on 90-acre tract.	Grand total, Red Hills.
Sept. 26, 1885	Wm M. Fitzhugh	225.36		51.73	(2.02)	6.61 9.61 16.22		293.31	295.33	56.47	45.27	(9.00)		(1.00)				10.81	111.74	406.07
Nov. 30, 1886	J. P. Culver.	261.43	64.67	11.46	2.02			337.56	339.57	9.50	5.70 97.80 .90 104.40	18.40		2.16		(a)		21.83	134.46	474.03
July 24, 1887	F. Eaton	147.50	169.50	(10.00)	(2.00)	163.00		327.00	329.00	13.67	31.90	10.00	(b)	(1.00)		(16.76)		14.50	73.33	402.33
July 13, 1888	J. P. Culver	155.78	183.61	18.10	c13.59	138.62	46.43	357.49	371.08	3.14	38.89	5.38	15.14	1.59	d17.70	16.76		17.76	98.60	469.68
July 13, 1889	E. T. Wright	184.58	163.57	18.27	9.78	136.23	48.96	361.42	371.20	3.94	40.53	17.33	15.14	1.81	54.02	(16.76)		20.97	149.53	520.73
July 14, 1890	.....do	260.03	228.53	17.32	10.85	156.01	72.52	505.88	516.73	3.08	71.98	30.53	13.98	0.92	e73.82	(16.76)		25.45	211.07	727.80
July 14, 1890	J. P. Culver	266.82	238.04	18.50	11.25	165.55	72.49	523.36	534.61	3.14	81.78	31.47	14.29	2.38	75.42	(16.76)		.....	225.24	759.85
June 29, 1893	E. T. Wright	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13.29	.....	.....	.....	.....	.....	19.82	.....	.....
July 14, 1893	.....do	.....	.....	.....	.....	152.42	.....	.....	.....	.....	.....	.....	.....	.....	36.45	.....	.....	.....	.....	.....
Sept. 15, 1894	.....do	f160.31	182.84	18.14	(8.00)	141.10	41.74	356.29	364.29	.....	.....	.....	.....	.....	.....	.....	.....	8.13	.....	.....
June 12, 1895	.....do	198.53	154.87	21.00	(7.00)	(110.60)	(44.27)	374.40	381.40	.....	.....	.....	.....	.....	.....	.....	.....	20.98	.....	.....
June 14, 1896	N. W. Stowell	.....	.....	.....	.....	.....	.....	.....	.....	0.00	22.00	1.00	23.00	.....	g18.00	.....	0.00	.....	64.00	352.55
Aug. 20, 1896	F. E. Trask	132.40	137.90	11.25	(7.00)	..	.	281.55	288.55	.....	.....	.....	.....	.....	.....	.....	.....	8.11	.....	.....

Mar. 2,1897	N. W Stowell															46.00			
Aug. 5 1897	do				9.42					0.00	20.00 7.00 27.00	(0.50)	h20.25	0.00	41.40	0.00		89.15	334 07
Aug 10.1897	F E Trask	104.90	120.10	10.50	f(9.42)			235.50	244.92	0.30							16.74		
Aug. 13,1898	do	76.68	95.91	7.84	f47.00			180.43	227.43	0.00							8.24		
Aug. 14,1898	N. W Stowell									0.00	k24.00	(0.50)	l13.00	0.00	26.00	0.00		63.50	280.93
Apr. 1,1899	do	107.25	98.20					205.45									7.49		
Aug 21,1899	E T. Wright.	m91.58	80.95		n27.00 o75.00	56.17	24.78	172.53	n199.53 p247.53	0.00									
Aug 25 1899	E.T. Wright and F. C. Finkle										3.13		2.68		61.80		92.40	67.61	267.14
Apr. 1,1899	Newman and Finkle.	107.25	98.20	(5.00)	q35.60	72.60		210.45	246.05	0.00	q15.49		7.90						
Feb. 3 and 5,1900.	Newman, Trask, and Finkle	m97.06	77.22		17.06	54.88		174.28	191.34	0.00	3.91		1.45						
Feb. 11,1900	Trask and Finkle										3.81	0.56	1.20		55.90		76.25	61.47	252.81

a China garden included in "D."
b Fall, 1897.
c Tunnel.
d Construction begun January, 1898.
e Length, 2,600 feet.
f 1 p. m.
g Caved in.
h August 4, well No. 2 cut.
i Exterior of tunnel begun, 11.
j Stowell.
k June 12, not pumped.
l July 24, not pumped.
m And China cienega.
n Flow.
o Pumped.
p When Lone Star Tunnel was pumped.
q March 15.

Discharge measurements of tributaries of Cucamonga Creek around Red Hills.

Date.	Hydrographer.	Discharge	Locality.
		Sec.-feet.	
Sept. 9, 1898	O. J. Sutton	2.20	Springs.
Do	do	2.80	Tunnels.
Do	do	1.80	Artesian wells.
Total		6.80	
Aug. 29, 1899	S. G. Bennett	2.48	From Stowell wells to Ontario.
July 11, 1900	S. G. Bennett	4.03	East side.
Do	do	2.97	West side.
Do	do	2.13	San Antonio water. Haskell well.
Do	do	1.72	Sixteenth street wells.
Total from Red Hills.		10.85	

DALEY DITCH, SAN BERNARDINO COUNTY.

See San Bernardino Valley, Daley ditch.

DEER CREEK.

Estimated monthly discharge of Deer Creek, Tulare County, at base of foothills

[Drainage area, 110 square miles.]

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth
1878.	*Second-feet.*	*Acre-feet.*	*Second-feet.*	*Inches*
November	0	0	0	0
December	0	0	0	0
1879.				
January	9	553	0.03	0.8
February	15	833	.14	.15
March	8	492	.07	.8
April	28	1,666	.25	.28
May	20	1,230	.18	.21
June	7	417	.06	.07
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	29	1,726	.26	.29
December	55	3,382	.50	.58
The year	14	10,299	.13	1.77

[a] Authority, California State engineering department. Estimated from run-off of neighboring streams.

Estimated monthly discharge of Deer Creek, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1880.	*Second-feet.*	*Acre-feet.*	*Second-feet.*	*Inches.*
January	132	8,116	1.20	1.38
February	253	14,553	2.30	2.48
March	286	17,585	2.60	3.00
April	319	18,982	2.90	3.24
May	220	13,527	2.00	2.31
June	55	3,273	.50	.56
July	6	369	.05	.06
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	22	1,309	.20	.22
December	55	3,382	.50	.58
The year	112	81,096	1.02	13.83
1881.				
January	55	3,382	.50	.58
February	110	6,109	1.00	1.04
March	110	6,764	1.00	1.15
April	110	6,545	1.00	1.12
May	110	6,764	1.00	1.15
June	55	3,273	.50	.56
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	0	0	0	0
December	23	1,414	.21	.24
The year	48	34,251	.43	5.84

Estimated monthly discharge of Deer Creek, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile	Depth.
1882.	*Second-feet.*	*Acre-feet*	*Second-feet.*	*Inches*
January	23	1,414	0.21	0.24
February	17	944	.15	.16
March	55	3,382	.50	.58
April	55	3,273	.50	.56
May	11	676	.10	.12
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	11	676	.10	.12
November	17	1,012	.15	.17
December	6	369	.05	.06
The year	16	11,746	.15	2.01
1883.				
January	17	1,045	.15	.17
February	17	944	.15	.16
March	88	5,411	.80	.92
April	55	3,273	.50	.56
May	44	2,705	.40	.46
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	11	676	.10	.12
November	11	655	.10	.11
December	17	1,045	.15	.17
The year	22	15,754	.21	2.67

Estimated monthly discharge of Deer Creek, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1884.	*Second-feet.*	*Acre-feet.*	*Second-feet.*	*Inches.*
January	55	3,382	0.50	0.58
February	330	18,982	3.00	3.24
March	330	20,291	3.00	3.46
April	220	13,091	2.00	2.23
May	44	2,705	.40	.46
June	55	3,273	.50	.56
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0

DINSMORE CREEK.

Discharge measurement of Dinsmore Creek, Santa Barbara County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Aug. —, 1889	G. F. Wright	0.23

DOBBINS CREEK.

Discharge measurement of Dobbins Creek, Yuba County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Apr. 29, 1901	F. S. Hyde	*a* 224

a Estimated, at dam.

DOS PUEBLOS CREEK.

Discharge measurement of Dos Pueblos Creek, Santa Barbara County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Aug. —, 1889	G. F. Wright	0.54

DRY OR JACKSON CREEK.

Estimated monthly discharge of Dry Creek, San Joaquin County, at base of foothills. [a]

[Drainage area, 283 square miles.]

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth
1878.	*Second-feet.*	*Acre-feet.*	*Second-feet.*	*Inches.*
November	0	0	0	0
December	0	0	0	0
1879.				
January	84	5,165	0.30	0.35
February	425	23,603	1.50	1.56
March	849	52,203	3.00	3.46
April	425	25,289	1.50	1.67
May	113	6,948	.40	.46
June	57	3,392	.20	.22
July	15	922	.05	.06
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	0	0	0	0
December	198	12,175	.70	.81
The year	181	129,697	.64	8.70
1880.				
January	127	7,809	.45	.52
February	140	8,053	.49	.51
March	354	21,767	1.25	1.44
April	2,264	134,717	8.00	8.92
May	879	54,048	3.11	3.59
June	113	6,724	.40	.45
July	15	922	.05	.06
August	6	369	.02	.02
September	0	0	0	0
October	0	0	0	0
November	0	0	0	0
December	142	8,731	.50	.58
The year	337	243,140	1.19	16.13

[a] Authority, California State engineering department. Estimated from run-off of neighboring streams.

Estimated monthly discharge of Dry Creek, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1881.	*Second-feet.*	*Acre-feet.*	*Second-feet.*	*Inches.*
January	879	54,048	3.11	3.59
February	1,557	86,471	5.50	5.73
March	566	34,802	2.00	2.31
April	566	33,679	2.00	2.23
May	113	6,948	.40	.46
June	42	2,499	.15	.17
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	57	3,392	.20	.22
December	254	15,618	.90	1.04
The year	336	237,457	1.19	15.75
1882.				
January	254	15,618	.90	1.04
February	283	15,717	1.00	1.04
March	849	52,203	3.00	3.46
April	566	33,679	2.00	2.23
May	57	3,505	.20	.23
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	15	893	.05	.06
October	57	3,505	.20	.23
November	84	4,998	.30	.33
December	84	5,165	.30	.35
The year	187	135,283	.66	8.97

Estimated monthly discharge of Dry Creek, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1883.	*Second-feet.*	*Acre-feet.*	*Second-feet.*	*Inches*
January	168	10,330	0.59	0.68
February	141	7,831	.50	.52
March	254	15,618	.90	1.04
April	283	16,840	1.00	1.12
May	168	10,330	.59	.68
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	15	922	.05	.06
November	0	0	0	0
December	15	922	.05	.06
The year	87	62,793	.31	4.16
1884.				
January	142	8,731	.50	.58
February	1,132	65,113	4.00	4.31
March	1,132	69,604	4.00	4.61
April	879	52,304	3.11	3.47
May	168	10,330	.59	.68
June	283	16,840	1.00	1.12
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0

EAST RIVERSIDE WATER COMPANY, SAN BERNARDINO COUNTY.

See San Bernardino Valley.

EATON CANYON.

Discharge measurements of Eaton Canyon, Los Angeles County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Jan. 11, 1899	E. P. Dewey	0.50	Near falls.
Oct. 18, 1898	J. B. Lippincott	1.87	Water from large wells in Eaton Wash.
Do	do	.04	Around superintendent's house and barns.
Do	do	.10	San Gabriel water.
Do	do	.10	Dairy well.
Nov. 14, 1898	do	2.11	

ELEANOR CREEK.

See Tuolumne River, Eleanor Creek.

FALLS CREEK.

See Tuolumne River, Falls Creek.

FALL RIVER.

See Pit River, Fall River.

FEATHER RIVER.

Discharge measurements of Feather River, Butte County.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
		Feet.	*Sec.-feet.*	
Feb. 18, 1879	State engineering department.	.....	21,000	Hennesseys.
May 13, 1879	do	.....	15,000	Do.
Feb. 19, 1879	do	.....	12,000	Burts Ferry.
Aug. 31, 1879	do	.....	1,200	Do.
Nov. 12, 1879	do	.....	2,700	Do.
Mar. 6, 1879	do	.....	56,000	Marysville.
Sept. 1, 1879	do	.....	1,200	Do.
July 16, 1879	do	.....	1,900	Near mouth.
Aug. 27, 1879	do	.....	1,200	Oroville.
Sept. 1, 1879	do	.....	1,800	Below mouth of Yuba.
Sept. 7, 1901	S. G. Bennett	.....	34	West Branch of North Fork, Cherokee Pipe Crossing.
Sept. 18, 1900	do	.....	1,123	Oroville Bridge.
Sept. 6, 1901	do	.....	1,220	Do.

Discharge measurements of Feather River, Butte County—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
		Feet.	*Sec.-feet.*	
Jan. 29, 1902	S. G. Bennett		1,960	Oroville Bridge.
Sept. 7, 1901	do		946	North Fork, Huffs Bar.
Mar. 1, 1902	do	8.7	15,228	Oroville Bridge.
May 7, 1902	do	8.75	15,476	Do.
Sept. 4, 1902	Chas. A. Miller	.96	1,385	Do.
Sept. 10, 1902	do	.92	1,390	Do.
Dec. 18, 1902	S. G. Bennett	3.65	3,298	Do.
Sept. 3, 1902	do		1	South Fork at Little Grass Valley.
Sept. 6, 1902	Chas. A. Miller		1	South Fork at bridge at Enterprise.
Do	do		216	South Fork at Bidwell Bar Bridge.
Do	do		30	South Fork Palermo Canal at Enterprise.
Sept. 4, 1902	S. G. Bennett		92	Middle Fork, below mouth of Nelson Creek.
Do	do		33	Middle Fork, Nelson Creek above mouth.
Do	do		28	Middle Fork, Spanish Creek at Pocket Bridge, lower end of American Valley.
Sept. 5, 1902	do		22	North Fork, Indian Creek at Indian Valley on Taylorsville road.
Do	do		607	North Fork at lower end Big Meadows.
Sept. 8, 1902	do		669	North Fork at Bidwell's sawmill.
Do	do		163	East Branch North Fork at Hamilton's bridge.
Sept. 9, 1902	do		64	Big Spring Branch of East Fork of North Fork at point 1 mile below boathouse.
Do	do		109	Dotta or Lower Big Spring Branch of North Fork at mouth.
Do	do		327	West Branch of North Fork near Prattville.
Sept. 7, 1902	do		27	Butte Valley Creek, North Fork, at Butte Valley post-office.
Sept. 9, 1902	Chas. A. Miller		595	North Fork, Huffs Bar.
Sept. 12, 1902	do		315	Big Bend Tunnel on North Fork, at portal of tunnel.
Sept. 9, 1902	do		27	West Fork of North Fork at Yankee Hill Bridge.

Estimated monthly discharge of Feather River at Oroville, Cal.

[Drainage area, 3,950 square miles.]

Month.	Discharge.			Total discharge	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1902.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	2,325	1,975	1,998	122,852	0.60	0.69
February	38,680	1,975	19,545	1,085,474	5.83	6.07
March	24,420	7,000	11,148	685,464	3.33	3.84
April	39,600	8,300	19,485	1,159,437	5.82	6.50
May	16,600	9,020	12,110	744,615	3.61	3.74
June	10,900	2,750	5,609	333,759	1.67	1.86
July	2,750	1,620	2,098	129,001	.63	.72
August	1,620	1,400	1,535	94,383	.46	.53
September	1,400	1,300	1,323	78,724	.40	.45
October	3,150	1,300	1,503	92,477	.45	.52
November	14,400	1,510	3,481	207,134	1.04	1.08
December	25,800	1,565	6,287	386,573	1.88	2.17
The year	39,600	1,300	7,177	5,119,893	2.14	28.57

FICAY CREEK.

Discharge measurement of Ficay Creek, Santa Barbara County.

Date.	Hydrographer.	Discharge
		Sec.-feet.
Aug.—, 1889	G. F. Wright	0.31

FORT TEJON CREEK.

Discharge measurement of Fort Tejon Creek, in foothills, Kern County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Nov. 13, 1895	J. B. Lippincott	2.6
Feb. 3, 1896	do	3.5
June 4, 1896	do	1.1
Dec. 19, 1896	do	1.5

FRESNO CREEK.

Estimated monthly discharge of Fresno Creek, Madera County, at base of foothills.[a]

[Drainage area, 272 square miles.]

Month.	Maximum.	Minimum.	Mean.	Total discharge.	Run-off.	
					Per square mile.	Depth
1878.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
November[b]			0	0	0	0
December[b]			0	0	0	0
1879.						
January[c]	80	0	27	1,660	0.10	0.12
February[c]	117	66	80	4,443	29	.30
March[c]	202	66	118	7,256	.43	.50
April[c]	202	124	156	9,283	.57	.64
May[c]	102	66	79	4,858	.29	.33
June[c]	54	0	15	893	.06	.07
July[c]	0	0	0	0	0	0
August[c]	0	0	0	0	0	0
September[c]	0	0	0	0	0	0
October[c]	0	0	0	0	0	0
November[b]	0	0	0	0	0	0
December[b]			109	6,702	.40	.46
The year			49	35,095	.18	2.42
1880.[b]						
January			5	307	.02	.02
February			150	8,628	.55	.59
March			16	984	.06	.07
April			1,088	64,740	4.00	4.46
May			54	3,320	.20	.23
June			27	1,607	.10	.11
July			0	0	0	0
August			0	0	0	0
September			0	0	0	0
October			0	0	0	0
November			0	0	0	0
December			218	13,404	.80	.92
The year			130	92,990	.48	6.49

[a] Authority, California State engineering department.

[b] November and December, 1878, and from November, 1879, to October, 1884, inclusive, estimated from run-off of neighboring streams.

[c] Measured.

Estimated monthly discharge of Fresno Creek, etc.—Continued.

Month.	Maximum.	Minimum.	Mean.	Total discharge.	Run-off. Per square mile.	Run-off. Depth.
1881.[a]	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January			544	33,449	2.00	2.31
February			544	30,212	2.00	2.08
March			272	16,725	1.00	1.15
April			109	6,486	.40	.45
May			54	3,320	.20	.23
June			0	0	0	0
July			0	0	0	0
August			0	0	0	0
September			0	0	0	0
October			0	0	0	0
November			0	0	0	0
December			27	1,660	.10	.12
The year			129	91,852	.48	6.34
1882.[a]						
January			54	3,320	.20	.23
February			163	9,053	.60	.62
March			1,088	66,899	4.00	4.61
April			272	16,185	1.00	1.12
May			54	3,320	.20	.23
June			0	0	0	0
July			0	0	0	0
August			0	0	0	0
September			0	0	0	0
October			27	1,660	.10	.12
November			54	3,213	.20	.22
December			27	1,660	.10	.12
The year			145	105,310	.53	7.27

[a] November and December, 1878, and from November, 1879, to October, 1884, inclusive, estimated from run-off of neighboring streams.

Estimated monthly discharge of Fresno Creek, etc.—Continued.

Month.	Maximum.	Minimum.	Mean.	Total discharge.	Run-off. Per square mile.	Run-off. Depth
1883.[a]	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January			82	5,042	0.30	0.35
February			54	2,999	.20	.21
March			272	16,725	1.00	1.15
April			136	8,093	.50	.56
May			109	6,702	.40	.46
June			0	0	0	0
July			0	0	0	0
August			0	0	0	0
September			0	0	0	0
October			0	0	0	0
November			0	0	0	0
December			0	0	0	0
The year			54	39,561	.20	2.73
1884.[a]						
January			27	1,660	.10	.12
February			1,360	78,228	5.00	5.59
March			1,632	100,348	6.00	6.92
April			1,088	64,740	4.00	4.46
May			816	50,174	3.00	3.46
June			816	48,555	3.00	3.35
July			272	16,725	1.00	1.15
August			27	1,660	.10	.12
September			0	0	0	0
October			0	0	0	0

[a] November and December, 1878, and from November, 1879, to October, 1884, inclusive, estimated from run-off of neighboring streams.

GAGE CANAL.

See San Bernardino Valley, Gage canal.

GATO CREEK.

Gato Creek was measured by Charles J. Johansen for the Pacific Improvement Company, as given below. It was gaged a short distance above its junction with the Loma Abajo, and at the time of its measurement no water was being conveyed in the pipe line situated along this stream.

Discharge measurements of Gato Creek, Santa Barbara County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Feb. 7, 1890	Charles J. Johansen	2.26	At mouth.
Feb. 14, 1890	....do	2.37	Do.
Feb. 27, 1890	....do	2.81	Do.
Mar. 2, 1890	....do	2.05	Do.
Mar. 4, 1890	....do	1.95	Do.
Mar. 6, 1890	....do	1.85	Do.
Mar. 9, 1890	....do	1.85	Do.
Mar. 11, 1890	....do	1.65	Do.
Mar. 13, 1890	....do	1.55	Do.
Mar. 15, 1890	....do	1.45	Do.
Mar. 17, 1890	....do	1.36	Do.
Mar. 21, 1890	....do	1.45	Do.
Mar. 23, 1890	....do	1.36	Do.
Mar. 25, 1890	....do	1.27	Do.
Mar. 27, 1890	....do	1.09	Do.
Mar. 29, 1890	....do	1.09	Do.
Mar. 31, 1890	....do	1.00	Do.
Apr. 2, 1890	....do	1.00	Do.
Apr. 4, 1890	....do	.92	Do.
Apr. 6, 1890	....do	.92	Do.
Apr. 8, 1890	....do	.92	Do.
Apr. 10, 1890	....do	.83	Do.
Apr. 12, 1890	....do	.83	Do.
Apr. 14, 1890	....do	.76	Do.
Apr. 16, 1890	....do	.76	Do.
Apr. 17, 1890	....do	.68	Do.
Apr. 18, 1890	....do	.76	Do.
Apr. 20, 1890	....do	.76	Do.
Apr. 22, 1890	....do	.76	Do.
Apr. 24, 1890	....do	.68	Do.
Apr. 26, 1890	....do	.68	Do.
Apr. 28, 1890	....do	.60	Do.
Apr. 30, 1890	....do	.68	Do.
May 2, 1890	....do	.60	Do.

Discharge measurements of Gato Creek, Santa Barbara County—Continued.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
May 4, 1890	Charles J. Johansen	0.68	At mouth.
May 6, 1890	do	.68	Do.
May 8, 1890	do	.60	Do.
May 10, 1890	do	.53	Do.
May 12, 1890	do	.53	Do.
May 14, 1890	do	.46	Do.
May 16, 1890	do	.53	Do.
May 18, 1890	do	.46	Do.
May 20, 1890	do	.46	Do.
May 22, 1890	do	.59	Do.
May 24, 1890	do	.59	Do.
May 26, 1890	do	.58	Do.
May 28, 1890	do	.56	Do.
May 30, 1890	do	.56	Do.
June 1, 1890	do	.54	Do.
June 3, 1890	do	.49	Do.
June 5, 1890	do	.50	Do.
June 7, 1890	do	.49	Do.
June 9, 1890	do	.44	Do.
June 11, 1890	do	.50	Do.
June 13, 1890	do	.45	Do.
June 15, 1890	do	.50	Do.
June 17, 1890	do	.58	Do.
June 19, 1890	do	.50	Do.
June 21, 1890	do	.49	Do.
June 23, 1890	do	.44	Do.
June 25, 1890	do	.47	Do.
June 27, 1890	do	.45	Do.
June 29, 1890	do	.42	Do.
July 1, 1890	do	.44	Do.
July 3, 1890	do	.49	Do.
July 5, 1890	do	.34	Do.
July 7, 1890	do	.35	Do.
July 9, 1890	do	.32	Do.
July 11, 1890	do	.34	Do.
July 13, 1890	do	.34	Do.
July 15, 1890	do	.35	Do.
July 17, 1890	do	.33	Do.
July 19, 1890	do	.35	Do.
July 21, 1890	do	.37	Do.
July 23, 1890	do	.32	Do.

Discharge measurements of Gato Creek, Santa Barbara County—Continued.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
July 25, 1890	Charles J. Johansen	0.26	At mouth.
July 27, 1890	....do	.32	Do.
July 29, 1890	....do	.34	Do.
July 31, 1890	....do	.34	Do.
Aug. 2, 1890	....do	.34	Do.
Aug. 4, 1890	....do	.34	Do.
Aug. 6, 1890	....do	.29	Do.
Aug. 8, 1890	....do	.27	Do.
Aug. 10, 1890	....do	.32	Do.
Aug. 12, 1890	....do	.35	Do.
Aug. 14, 1890	....do	.30	Do.
Aug. 15, 1890	....do	.27	Do.
Aug. 17, 1890	....do	.26	Do.
Aug. 19, 1890	....do	.28	Do.
Aug. 21, 1890	....do	.35	Do.
Aug. 23, 1890	....do	.28	Do.
Aug. 25, 1890	....do	.30	Do.
Aug. 27, 1890	....do	.30	Do.
Aug. 29, 1890	....do	.28	Do.
Aug. 31, 1890	....do	.26	Do.
Sept. 2, 1890	....do	.22	Do.
Sept. 4, 1890	....do	.22	Do.
Sept. 6, 1890	....do	.26	Do.
Sept. 8, 1890	....do	.26	Do.
Sept. 10, 1890	....do	.26	Do.
Sept. 12, 1890	....do	.26	Do.
Sept. 14, 1890	....do	.22	Do.
Sept. 16, 1890	....do	.22	Do.
Sept. 18, 1890	....do	.26	Do.
Sept. 21, 1890	....do	.30	Do.
Sept. 22, 1890	....do	.22	Do.
Sept. 24, 1890	....do	.22	Do.
Sept. 26, 1890	....do	.22	Do.
Sept. 28, 1890	....do	.37	Do.
Sept. 30, 1890	....do	.60	Do.
Oct. 2, 1890	....do	.42	Do.
Oct. 4, 1890	....do	.35	Do.
Oct. 6, 1890	....do	.30	Do.
Oct. 7, 1890	....do	.30	Do.

GAZOO CREEK.

Discharge measurements of Gazoo Creek, San Mateo County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Oct. 17, 1893	W. W. Brier	1.85	6 miles above mouth.

GORMAN CREEK.

See Piru Creek, Gorman Creek.

GREEN SPOT PIPE LINE.

See Santa Ana River, Green Spot pipe line.

GRINDSTONE CREEK.

See Stony Creek, Grindstone Creek.

GUBERNADOR CREEK.

Discharge measurement of Gubernador Creek, Santa Barbara County.

Date.	Hydrographer.	Discharge.	Locality
		Sec.-feet.	
Aug. —, 1889	G. F. Wright	0.58	

HAT CREEK.

See Pit River, Hat Creek.

HAWS AND TALMAGE DITCH.

See San Bernardino Valley, Haws and Talmage ditch.

HONEY LAKE.

Annual inflow estimated by State engineering department 200,000 acre-feet.

HOUSE CREEK.

See Tejon House Creek.

KAWEAH RIVER.

Discharge measurements of Kaweah River, Tulare County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Nov. 20, 1895	J. B. Lippincott	70	Headworks above upper large power canal.
Sept. 1, 1898	do	35	Do.
Sept. 6, 1899	S. G. Bennett	41	Do.
Sept. 3, 1900	do	78.5	Do.
Nov. 20, 1895	J. B. Lippincott	0	Iron bridge, wagon road.
Aug. 31, 1898	do	0	Southern Pacific branch railroad bridge.
Sept. 1, 1898	do	18	Iron bridge, wagon road.
Sept. 6, 1899	S. G. Bennett	33	Do.
Sept. 3, 1900	do	72	1,000 feet below iron bridge.
Do	do	15	Watumna Canal at head-gate.
Oct. 20, 1901	do	52	Iron bridge, 1,000 feet below.
Do	do	5	Watumna Canal.
Aug. 31, 1898	J. B. Lippincott	8.5	Kaweah irrigation and power ditch (Pogues lower ditch).
Sept. 6, 1899	S. G. Bennett	1.5	Do.
Sept. 3, 1900	do	8.1	Do.
Do	do	1	Myers ditch above Pogues upper ditch.
Aug. 31, 1898	J. B. Lippincott	4.5	Pogues upper ditch.
Sept. 6, 1899	S. G. Bennett	4.9	Do.
Sept. 3, 1900	do	6.7	Do.
Sept. 1, 1898	J. B. Lippincott	.3	North Fork at mouth.
Sept. 6, 1899	S. G. Bennett	1.1	Do.
Sept. 1, 1898	J. B. Lippincott	0	South Fork canals.
Sept. 6, 1899	S. G. Bennett	.7	Do.
Sept. 25, 1902	E. T. Perkins	4.3	North Fork at lower end Davis ranch.
Do	do	.7	South Fork, 200 yards above bridge on road to Visalia.
Sept. 26, 1902	do	29	Middle Fork, ¼ mile above Sequoia National Park line.
Sept. 27, 1902	do	20	Middle Fork, 100 yards above junction with Marble Fork.
Do	do	4	Marble Fork, 100 yards above junction with Middle Fork.
Do	do	15	East Fork, ½ mile above headworks Mount Whitney power plant.
Do	do	15.5	East Fork, 200 feet below headworks Mount Whitney power plant.
Sept. 28, 1902	do	11	East Fork, 100 yards below trail from Soldiers' Camp to Tar Gap.

Discharge measurements of Kaweah River, Tulare County—Continued.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Sept. 29, 1902	E. T. Perkins	1	South Fork, Horse Creek, at lower end Hackett Meadows.
Do	do	2	South Fork, lower end Sand Meadows.
Sept. 27, 1902	L. M. Lawson	33	¼ mile above iron bridge.
Sept. 29, 1902	do	9.8	South Fork, at Sequoia National Park line.
Sept. 30, 1902	do	31	Middle Fork, 3 miles above Three Rivers.
Sept. 10, 1902	R. McF. Doble	31	Middle Fork, ¼ mile inside Sequoia National Park line.
Sept. 12, 1902	do	18	East Fork (total flow), 1,600 feet from head of Mount Whitney Power Co. flume.

Estimated monthly discharge of Kaweah River at Wachumna Hill, Tulare County.[a]

[Drainage area, 619 square miles.]

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1878.	*Second-feet.*	*Acre-feet.*	*Second-feet.*	*Inches.*
November [b]	155	9,223	0.25	0.28
December [b]	155	9,531	.25	.29
1879.				
January [c]	248	15,249	.40	.46
February [c]	279	15,495	.45	.47
March [c]	402	24,718	.65	.75
April [c]	867	51,590	1.40	1.56
May [c]	774	47,591	1.25	1.44
June [c]	557	33,144	.90	1.00
July [c]	124	7,624	.20	.23
August [c]	31	1,906	.05	.06
September [b]	31	1,845	.05	.06
October [b]	62	3,812	.10	.12
November [c]	124	7,379	.20	.22
December [c]	279	17,155	.45	.52
The year	315	227,508	.51	6.89

[a] Authority, California State engineering department.
[b] Estimated in part from run-off of neighboring streams.
[c] Based in part on measurements and rod records near Three Rivers.

Estimated monthly discharge of Kaweah River, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1880.	*Second-feet.*	*Acre-feet.*	*Second-feet.*	*Inches.*
January [a]	248	15,249	0.40	0.46
February [a]	310	17,831	.50	.54
March [a]	464	28,530	.75	.86
April [a]	2,352	139,954	3.80	4.24
May [a]	2,786	171,304	4.50	5.19
June [a]	3,900	232,066	6.30	7.02
July [a]	743	45,685	1.20	1.38
August [b]	155	9,531	.25	.29
September [b]	99	5,891	.16	.18
October [b]	50	3,074	.08	.09
November [b]	74	4,403	.12	.13
December [b]	371	22,812	.60	.69
The year	963	696,330	1.56	21.07
1881.				
January [b]	526	32,342	.85	.98
February [b]	774	42,986	1.25	1.30
March [b]	619	38,061	1.00	1.15
April [b]	1,393	82,889	2.25	2.51
May [b]	1,238	76,122	2.00	2.31
June [b]	990	58,909	1.60	1.79
July [a]	371	22,812	.60	.69
August [a]	155	9,531	.25	.29
September [a]	43	2,559	.07	.08
October [a]	74	4,550	.12	.14
November [a]	124	7,379	.20	.22
December [a]	279	17,155	.45	.52
The year	549	395,295	.89	11.98

[a] Based in part on measurements and rod records near Three Rivers.
[b] Estimated in part from run-off of neighboring streams.

Estimated monthly discharge of Kaweah River, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth
1882.	*Second-feet.*	*Acre-feet.*	*Second-feet.*	*Inches.*
January [a]	155	9,531	0.25	0.29
February [a]	310	17,217	.50	.52
March [a]	464	28,530	.75	.86
April [a]	1,393	82,889	2.25	2.51
May [a]	2,228	136,994	3.60	4.15
June [a]	929	55,279	1.50	1.67
July [b]	743	45,685	1.20	1.38
August [b]	198	12,175	.32	.37
September [b]	93	5,534	.15	.17
October [b]	87	5,349	.14	.16
November [b]	124	7,379	.20	.22
December [b]	93	5,718	.15	.17
The year	568	412,280	.92	12.47
1883. [b]				
January	155	9,531	.25	.29
February	124	6,887	.20	.21
March	619	38,061	1.00	1.15
April	805	47,901	1.30	1.45
May	1,021	62,779	1.65	1.90
June	990	58,909	1.60	1.78
July	402	24,718	.65	.75
August	99	6,087	.16	.18
September	74	4,403	.12	.14
October	62	3,812	.10	.12
November	74	4,403	.12	.13
December	74	4,550	.12	.14
The year	375	272,041	.61	8.34

[a] Based in part on measurements and rod records near Three Rivers.
[b] Estimated in part from run-off of neighboring streams.

Estimated monthly discharge of Kaweah River, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1884.[a]	*Second-feet.*	*Acre-feet.*	*Second-feet.*	*Inches.*
January	248	15,249	0.40	0.46
February	2,177	125,222	3.52	3.80
March	2,290	140,807	3.70	4.27
April	1,548	92,112	2.50	2.79
May	2,847	175,055	4.60	5.30
June	4,271	254,142	6.90	7.69
July	3,497	215,022	5.65	6.51
August	990	60,873	1.60	1.84
September	495	29,455	.80	.89
October	248	15,249	.40	.46

[a] Estimated in part from run-off of neighboring streams.

KERN RIVER.

The gaging station on Kern River, established in 1893 by Mr. Walter Jones, chief engineer of the Kern County Land Company, is located at what is known as first point of measurement, 5 miles above Bakersfield. Meter measurements are taken once a week and an automatic gage records daily fluctuations of the river heights. Mr. A. K. Warren, the engineer in charge of this work for the Kern County Land Company, attends to the discharge measurements with much accuracy and precision, and furnishes the Survey with the final results.

Discharge measurements of Kern River, Kern County.

Date.	Hydrographer.	Discharge.	Locality.
		Second-feet.	
Feb. 10, 1897	J. B. Lippincott	314	Calloway Canal at second point of measurement.
July 17, 1898	F. H. Olmsted	5.3	Menache Meadows, Tulare County.
July 10, 1898	do	12.9	South Fork at mouth, Kern County.
July 11, 1898	do	17.9	Do.
July 13, 1898	do	10.1	South Fork, sec. 6–22–36, Kern County.
July 10, 1898	do	331	North Fork at mouth, Kern County.
June 29, 1896	J. B. Lippincott	3,004	First point of measurement.
Aug. 29, 1898	do	116	Do.

Discharge measurements of Kern River, Kern County—Continued.

Date.	Hydrographer.	Discharge.	Locality.
		Second-feet.	
Sept. 2, 1899	S. G. Bennett	99	First point of measurement.
Aug. 30, 1900	A. K. Warren	103	Do.
Oct. 7, 1902	L. M. Lawson	171	Do.
Feb. 10, 1897	J. B. Lippincott	322	Calloway Canal at first point of measurement.
Sept. 2, 1899	F. H. Olmsted	99.22	Kern River, first point of measurement.
June 19, 1900	do	1.32	Basin Creek, Rankin's ranch, Walker's basin.
June 20, 1900	do	14.18	South Fork of Kern River, 700 feet above junction.
Do	do	1,333.17	North Fork of Kern River, Hooper's Mill Bridge.
June 21, 1900	do	2.30	Bull Run Creek near mouth.
June 22, 1900	do	2.92	Tobias Creek near mouth.
Do	do	.18	Ant Creek at mouth; elevation, 3,200 feet.
Do	do	3.45	Salmon Creek at mouth.
Do	do	.32	Corral Creek near mouth.
June 23, 1900	do	5.82	South Needles Creek at Needles Peak; elevation, 4,550 feet.
Do	do	5.19	Clark Creek, Dry Meadows.
Do	do	5.74	Jackson Creek, Dry Meadows.
Do	do	5.07	Wade Creek, Dry Meadows.
June 24, 1900	do	4.26	North Needles Creek at Needles Peak.
Do	do	81	Little Kern River at junction with Kern River.
June 25, 1900	do	2.87	Tibbetts Creek, 1 mile above mouth.
Do	do	8.45	Harris Creek at mouth.
Do	do	4.87	One Mile Creek, 1 mile below Kern Lake.
Do	do	1,154.90	North Fork of Kern River, 3,000 feet above junction with Little Kern River.
Do	do	4.72	Whitney Creek at tunnel in divide.
June 27, 1900	do	39.11	Whitney Creek at Lava bridge.
Do	do	17.64	Creek south of Bald Mountain; elevation, 6,560 feet.
Do	do	939.60	North Fork of Kern River, 800 feet above Kern Lake.
June 28, 1900	do	3.67	South Fork of Kern River, Manache Meadows.
June 29, 1900	do	1.80	Tibbetts Creek; elevation, 8,[illegible] feet.

Discharge measurements of Kern River, Kern County—Continued.

Date.	Hydrographer.	Discharge.	Locality.
		Second-feet.	
June 29, 1900	F. H. Olmsted	1.04	North Fork of Brush Creek; elevation, 5,800 feet.
Do	do	8.22	Brush Creek above North Fork; elevation, 5,600 feet.
June 30, 1900	do	825.25	North Fork of Kern River, 4,000 feet above junction with South Fork.
Do	do	4.05	Salmon Creek, Horse Meadows; elevation, 7,700 feet.
July 2, 1900	do	11.05	South Fork of Kern River, T. 25 S., R. 35 E., Mount Diablo meridian; elevation, 2,920 feet.
Do	do	2.38	Powers Ditch near head.
July 3, 1900	do	1.96	Neil's Ditch, Isabella.
Do	do	7.31	Hooper's Mill Ditch at gaging station on Kern River.
Oct. 4, 1902	E. T. Perkins	14	Little Kern 100 yards above junction.
Do	do	158	100 yards above junction with Little Kern.
Oct. 6, 1902	do	.5	Brown's upper ditch at road crossing to Hot Springs.
Do	do	7	Brown's main ditch at entrance to weir.
Do	do	1.5	Stafford & Neal ditch above Kernville.
Do	do	7.9	Brown's lower ditch above dairy.
Do	do	160	Power Company's diversion, Kernville.
Oct. 7, 1902	do	224	¼ mile above mouth of Salmon Creek.
Do	do	.5	Salmon Creek 50 yards above junction.
Do	do	127	Above gaging station, Kern River Power Co.
Oct. 8, 1902	do	188	¼ mile above powerhouse, Kern River Power Co.
Do	do	236	Below Clear Creek.
Do	do	201	200 yards below junction South Fork.
Do	do	18	South Fork above junction.
Do	do	202	350 yards below bridge from Isabella to Kernville.
Do	do	9	Hooper ditch at bridge from Isabella to Kernville.
Do	do	.6	Lower Stafford ditch ¼ mile north of Staffords ranch.

Discharge measurements of Kern River, Kern County—Continued.

Date.	Hydrographer.	Discharge.	Locality.
		Second-feet.	
Oct. 8, 1902	E. T. Perkins	0.7	Lower Murphy ditch 75 yards above Weldon road crossing.
Do	do	7	South Fork at Weldon road crossing.
Oct. 7, 1902	L. M. Lawson	174	½ mile below mouth of canyon.
Do	do	14	Below intake of Power Company's tunnel.
Oct. 8, 1902	do	179	Democrat Springs 200 feet below hotel at springs.

Estimated monthly discharge of Kern River at Rio Bravo ranch, Kern County.

[Drainage area, 2,345 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1878.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
November			400	23,802	0.17	0.19
December			350	21,521	.15	.17
1879.						
January	686	389	462	28,407	.20	.23
February	745	466	591	32,822	.25	.28
March	659	510	552	33,941	.24	.27
April	1,054	661	764	45,461	.33	.37
May	1,231	680	927	56,999	.40	.46
June	1,190	812	971	57,779	.41	.46
July	865	386	535	32,896	.23	.27
August	387	168	266	16,356	.11	.13
September	174	146	171	10,175	.07	.08
October	210	145	182	11,191	.08	.09
November	325	184	261	15,531	.11	.13
December	650	280	356	21,890	.15	.17
The year	1,231	145	503	363,448	.22	2.9

[a] Authority, California State engineering department, from November, 1878, to October, 1879, inclusive.

Estimated monthly discharge of Kern River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1880.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	410	315	354	21,767	0.15	0.17
February	380	315	370	21,283	.16	.17
March	385	349	389	23,919	.17	.20
April	3,320	395	1,557	92,648	.66	.74
May	3,560	1,615	2,659	163,496	1.13	1.30
June	4,070	2,740	3,317	197,375	1.41	1.57
July	3,140	1,550	2,196	135,027	.94	1.08
August	1,500	840	1,060	65,177	.45	.52
September	846	710	767	45,640	.33	.37
October	794	722	758	46,608	.32	.37
November	830	695	767	45,640	.33	.37
December	1,480	790	1,063	65,361	.45	.52
The year	4,070	315	1,271	923,941	.54	7.38
1881.						
January	1,640	950	1,078	66,284	.46	.53
February	2,970	1,430	1,773	98,467	.76	.79
March	2,100	1,400	1,570	96,536	.67	.77
April	2,612	2,100	2,288	136,145	.98	1.09
May	2,710	2,060	2,362	145,234	1.01	1.16
June	2,390	1,475	1,890	112,463	.81	.90
July	1,520	710	1,126	69,235	.48	.55
August	1,200	420	627	38,553	.27	.31
September	420	320	361	21,481	.15	.17
October	360	310	333	20,475	.14	.16
November	360	300	337	20,053	.14	.16
December	410	320	350	21,521	.15	.17
The year	2,970	300	1,175	846,447	.50	6.76

Estimated monthly discharge of Kern River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile	Depth
1882.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet*	*Sec.-feet.*	*Inches*
January	380	310	335	20,598	0.14	0.16
February	510	360	395	21,937	.17	.18
March	1,260	440	600	36,893	.26	.30
April	1,670	920	1,174	69,858	.50	.56
May	2,000	1,420	1,670	102,684	.71	.82
June	1,990	900	1,306	77,712	.56	.62
July	1,110	450	726	44,640	.31	.36
August			330	20,291	.14	.16
September			330	19,636	.14	.16
October			330	20,291	.14	.16
November [a]			280	16,661	.12	.13
December [a]			280	17,217	.12	.14
The year			646	468,418	.28	3.75
1883.[a]						
January			280	17,217	.12	.14
February			350	19,438	.15	.16
March			700	43,041	.30	.35
April			1,170	69,620	.50	.56
May			1,410	86,697	.60	.69
June			1,170	69,620	.50	.56
July			940	57,798	.40	.46
August			470	28,899	.20	.23
September			350	20,826	.15	.17
October			280	17,217	.12	.14
November			200	11,901	.09	.10
December			200	12,298	.09	.10
The year			627	454,572	.27	3.66

[a] Estimated from previous measurements and from run-off of neighboring streams.

Estimated monthly discharge of Kern River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1884.[a]	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January			350	21,521	0.15	0.17
February			470	27,035	.20	.22
March			940	57,798	.40	.46
April			1,980	117,818	.84	.94
May			5,860	360,317	2.50	2.88
June			9,380	558,149	4	4.46
July			5,860	360,317	2.50	2.88
August			2,350	144,496	1	1.15
September			940	55,934	.40	.45
October			470	28,899	.20	.23

[a] Estimated from previous measurements and from run-off of neighboring streams.

Estimated monthly discharge of Kern River at first point of measurement.[b]

[Drainage area, 2,345 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1893.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
October	554	517	534	32,861	0.23	0.26
November	559	467	518	30,827	.22	.24
December	590	430	516	31,757	.22	.25
1894.						
January	741	562	661	40,644	.28	.32
February	1,114	604	717	39,817	.30	.32
March	1,443	762	1,001	61,541	.43	.65
April	1,892	1,209	1,495	88,952	.64	.71
May	2,208	1,228	1,607	98,798	.69	.79
June	1,719	871	1,085	64,557	.46	.51
July	1,051	400	700	43,036	.30	.34
August	549	256	335	20,565	.14	.16
September	382	172	248	14,756	.11	.12
October	263	224	279	17,178	.12	.14
November	268	230	244	14,500	.10	.11
December	805	234	470	28,908	.20	.23
The year	2,208	172	737	533,252	.31	4.40

[b] Authority, Kern County Land Company.

Estimated monthly discharge of Kern River, etc.—Continued.

Month.	Discharge.				Run-off.	
	Maximum.	Minimum.	Mean.	Total discharge.	Per square mile.	Depth
1895.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
January	1,616	473	809	49,762	0.34	0.4
February	4,762	675	1,252	69,536	.53	.5
March	3,004	987	1,374	84,437	.59	.6
April	3,897	1,911	2,724	162,076	1.16	1.2
May	5,384	3,100	4,369	268,608	1.86	2.1
June	3,721	2,174	2,906	172,919	1.24	1.3
July	2,063	867	1,482	91,113	.63	.7
August	1,073	354	629	38,665	.27	.3
September	676	290	344	20,469	.15	.1
October	612	276	327	20,106	.14	.1
November	436	308	346	20,588	.15	.1
December	447	368	403	24,779	.17	.1
The year	5,384	276	1,413	1,023,058	.60	8.1
1896.						
January	3,101	377	747	45,931	.32	.3
February	798	559	617	35,489	.26	.2
March	2,089	652	951	58,475	.41	.4
April	1,263	766	972	57,838	.41	.4
May	3,370	934	1,401	86,144	.60	.6
June	3,611	1,244	2,456	146,142	1.05	1.1
July	2,210	741	1,316	82,762	.57	.6
August	741	353	486	29,883	.21	.2
September	473	234	304	18,089	.13	.1
October	425	223	267	16,417	.11	.1
November	416	288	355	21,124	.15	.1
December	426	313	347	21,336	.15	.1
The year	3,611	223	854	619,630	.36	4.9

Estimated monthly discharge of Kern River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1897.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	832	305	373	22,935	0.16	0.18
February	2,306	516	809	44,930	.35	.36
March	2,044	688	923	56,753	.39	.45
April	4,410	1,094	2,914	173,395	1.24	1.38
May	5,342	4,054	4,580	281,613	1.95	2.25
June	4,352	1,289	2,309	137,395	.98	1.09
July	1,536	644	1,006	61,857	.43	.49
August	671	338	469	28,838	.20	.23
September	363	260	295	17,554	.13	.14
October	441	278	340	20,906	.15	.17
November	477	289	355	21,124	.15	.17
December	1,023	327	422	25,948	.18	.21
The year	5,342	260	1,234	893,248	.53	7.12
1898.						
January	400	311	363	22,320	.15	.17
February	923	316	434	24,103	.19	.20
March	485	304	388	23,857	.17	.20
April	1,342	371	710	42,247	.30	.33
May	980	560	735	45,193	.31	.36
June	686	394	551	32,786	.23	.26
July	416	127	244	15,003	.10	.12
August	142	86	120	7,378	.05	.06
September	294	80	116	6,902	.05	.06
October	232	127	160	9,838	.07	.08
November	188	136	166	9,877	.07	.08
December	314	147	199	12,236	.08	.09
The year	1,342	80	348	251,743	.15	2.01

Estimated monthly discharge of Kern River, etc.—Continued.

Month.	Discharge.				Run-off.	
	Maximum.	Minimum.	Mean.	Total discharge.	Per square mile.	Depth
1899.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
January	361	182	263	16,172	0.11	0.1
February	365	258	302	16,772	.13	.1
March	4,932	247	590	36,278	.25	.2
April	1,167	593	893	53,138	.38	.4
May	1,302	576	835	51,342	.36	.4
June	2,230	809	1,331	79,200	.57	.6
July	894	229	489	30,057	.21	.2
August	240	99	156	9,592	.07	.0
September	117	89	105	6,257	.04	.0
October	229	86	160	9,838	.07	.0
November	385	183	221	13,151	.09	.1
December	781	182	277	17,032	1.18	1.3
The year	4,932	86	468	338,829	.29	3.9
1900.						
January	1,048	266	362	22,259	.15	.1
February	329	238	280	15,550	.12	.1
March	502	307	413	25,394	.18	.2
April	592	387	472	28,086	.20	.2
May	1,969	449	1,111	68,312	.47	.5
June	1,878	841	1,283	76,344	.55	.6
July	850	202	392	24,103	.17	.2
August	217	101	144	8,854	.06	.0
September	270	106	166	9,878	.07	.0
October	186	137	160	9,838	.07	.0
November	1,339	161	349	20,767	.15	.1
December	445	288	373	22,934	.16	.1
The year	1,969	101	459	332,319	.20	2.6

Estimated monthly discharge of Kern River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	2,049	226	493	30,313	0.21	0.24
February	1,963	342	860	47,762	.37	.39
March	1,658	901	1,270	78,089	.54	.62
April	2,632	637	1,398	83,187	.60	.67
May	4,419	2,091	3,032	186,430	1.29	1.49
June	4,332	2,455	3,324	197,792	1.42	1.58
July	3,856	1,120	1,864	114,163	.80	.92
August	1,804	505	968	59,520	.41	.47
September	526	249	345	20,529	.15	.17
October	756	259	317	19,492	.14	.16
November	421	343	377	22,433	.16	.18
December	457	268	323	19,860	.14	.16
The year	4,419	226	1,216	880,020	.52	7.05

KING RIVER.

This river rises on the western slope of the Sierra Nevada in Fresno County, Cal. The waters coming from the high catchment basin are probably of greater value for irrigation purposes than those of any other stream in central California, being used exclusively for the raising of grapes and deciduous fruits in the neighborhood of Fresno, Selma, and Hanford. The summer flow of this river is now entirely diverted, and during the dry season of the last few years the scarcity of water has worked many hardships. There is a large surplus of water in this river in the spring, due to the melting of snows, which is now going to waste, and which, if stored in suitable reservoirs, would bring larger areas under cultivation. The mountainous basin of this river has been systematically explored for reservoir sites. For a detailed statement concerning the hydrography of King River, see Water-Supply Paper No. 58, by J. B. Lippincott. Two gaging stations were formerly maintained on the river, one at Red Mountain and the other at Kingsburg, Cal. The station at Red Mountain, established September 3, 1895, is located 15 miles east of Sanger, Cal., and southwest of Red Mountain. The station is on what is called "the lower section of No. 9" of the lumber flume. It is located at the mouth of the canyon, above all diversions. The bed of the stream is of gravel, and few changes have been noticed in the cross section since the establishment of the station.

Discharge measurements of King River, Fresno County.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
		Feet.	*Sec.-feet.*	
June 20, 1900	E. G. Hamilton		21.7	Boulder Creek—Crossing of upper trail from Kings River Canyon to Bearskin Meadow.
Aug. 31, 1898	J. B. Lippincott		164	Church ditch (Fresno Canal), near head.
Sept. 4, 1899	S. G. Bennett		151	Do.
Sept. 4, 1900	do		229	Do.
Sept. 24, 1902	L. M. Lawson		121	Church ditch at road crossing.
Do	do		Dry.	Fowler Switch Canal, near head.
Sept. 4, 1899	S. G. Bennett		Dry.	Do.
Do	do		2	Gould Canal, near head.
Sept. 4, 1900	do		84	Do.
Sept. 27, 1900	do		1	Do.
Sept. 4, 1899	do		.3	Kingsburg Canal at head.
Sept. 4, 1900	do		Dry.	Do.
Sept. 24, 1902	L. M. Lawson		4.8	Kingsburg Canal at road crossing.
Sept. 17, 1902	E. T. Perkins		3.5	Dinkey Creek, 75 yards below bridge.
Do	do		1.5	Bear Creek.
Do	do		1.5	Deer Creek.
Sept. 18, 1902	do		7.2	North Fork, 100 yards above trail crossing.
Do	do		3	North Fork Creek below Crown Meadow.
Do	do		5	North Fork, Crown Creek.
Do	do		2	North Fork, Blue Canyon Creek.
Do	do		75	Middle Fork at Simpson Meadow.
Sept. 22, 1902	do		32	Bubbs Creek, 100 yards above junction.
Do	do		29	South Fork, 100 yards below trail crossing.
Do	do		.7	Granite Creek, 50 yards above bridge on trail crossing.
Do	do		1.5	Copper Creek.
Sept. 23, 1902	do		11	Roaring Creek at trail crossing.
Sept. 22, 1902	L. M. Lawson		35	North Fork at mouth.
Sept. 24, 1902	do		31	'76 Canal at Trimmer Springs road crossing.

Discharge measurements of King River, Fresno County—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
		Feet.	*Sec.-feet.*	
Sept. 22, 1902	L. M. Lawson		2	Enterprise Canal at Trimmer Springs road crossing.
Sept. 25, 1902	do		74	At bridge, 1 mile north of Reedley.
Jan. 10, 1895	A. P. Davis	6	1,830	Kingsburg.[a]
Mar. 23, 1895	J. B. Lippincott	4.1	500	Do.
Dec. 2, 1895	do	3.3	407	Do.
Apr. 11, 1896	J. A. Vogelson	5.7	1,883	Do.
Feb. 11, 1897	J. B. Lippincott	5.6	905	Do.
Apr. 6, 1897	do	5.2	825	Do.
June 3, 1897	do	8.6	5,959	Do.
July 17, 1897	do	5.2	503	Do.
Sept. 10, 1897	A. Q. Campbell	3.2	221	Do.
Nov. 3, 1897	do	4.8	465	Do.
Dec. 23, 1897	J. B. Lippincott	4.8	522	Do.
May 28, 1898	do	6.2	1,026	Do.
Apr. 21, 1898	do	6.6	1,658	Do.
July 26, 1898	do	3.9	305	Do.
Aug. 30, 1898	do	3.4	94	Do.
Sept. 26, 1902	L. M. Lawson		117	Do.
June 19, 1900	E. G. Hamilton		11.6	Long Valley, 300 feet below junction of Tenmile Creek.
Aug. 26, 1900	H. E. Green		153	Middle Fork at Tehipiti.
May 23, 1900	E. G. Hamilton		6.8	Mill Creek, sec. 13, T. 13 S., R. 24 E.
Aug. 19, 1900	do		4.3	North Fork, Dusy Meadows.
Sept. —, 1900	J. S. Eastwood		15	North Fork.
Sept. 3, 1895	A. P. Davis	4.3	524	Red Mountain.
Nov. 24, 1895	J. B. Lippincott	3.8	248	Do.
Apr. 12, 1896	J. A. Vogelson	6.35	1,745	Do.
June 12, 1896	J. B. Lippincott	10.85	15,941	Do.
Nov. 1, 1896	do	4.2	404	Do.
Feb. 13, 1897	do	5.2	1,021	Do.
Apr. 5, 1897	do	6.82	2,047	Do.
June 1, 1897	do	10.02	8,838	Do.
July 15, 1897	A. Q. Campbell	7.17	3,333	Do.
Sept. 9, 1897	do	4.1	295	Do.

[a] Grade of river at Kingsburg affected by diversion dam of Last Chance Company, 2 miles below.

Discharge measurements of King River, Fresno County—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
		Feet.	*Sec.-feet.*	
Nov. 1, 1897	A. Q. Campbell	4.57	552	Red Mountain.
Dec. 22, 1897	J. B. Lippincott	4.7	515	Do.
Apr. 20, 1898	do	8.55	4,943	Do.
May 29, 1898	do	7.14	2,672	Do.
July 27, 1898	do	4.32	503	Do.
Aug. 31, 1898	do	3.77	244	Do.
Dec. 21, 1898	do	7.0	2,444	Do.
Apr. 19, 1899	S. G. Bennett	8.8	5,409	Do.
May 15, 1899	do	8.15	4,422	Do.
June 3, 1899	do	7.85	3,954	Do.
June 26, 1899	do	7.23	3,049	Do.
Aug. 2, 1899	do	4.66	608	Do.
Sept. 4, 1899	do	3.80	206	Do.
Dec. 8, 1899	J. B. Lippincott	4.36	458	Do.
Apr. 4, 1900	S. G. Bennett	6.54	2,035	Do.
May 16, 1900	do	9.2	6,436	Do.
June 19, 1900	do	8.59	5,072	Do.
Aug. 10, 1900	do	4.3	427	Do.
Sept. 4, 1900	do	4.28	405	Do.
Sept. 27, 1900	do	3.82	220	Do.
Dec. 29, 1900	do	4.65	576	Do.
Jan. 31, 1901	do	5.4	991	Do.
Feb. 28, 1901	do	7.90	3,593	Do.
Apr. 4, 1901	do	6.40	1,915	Do.
May 21, 1901	J. B. Lippincott	10.5	10,869	Do.
July 30, 1901	S. G. Bennett	7.54	3,179	Do.
Oct. 17, 1901	do	4.1	301	Do.
Sept. 21, 1902	do	.....	217	Do.
Oct. 20, 1900	H. E. Green	.....	346	South Fork, just below junction of Middle Fork.
Sept. 4, 1899	S. G. Bennett	.....	Dry.	"76" ditch at head.
Sept. 4, 1900	do	.....	Dry.	Do.
June 25, 1895	J. B. Lippincott	13.9	10,307	Suspension bridge.
Sept. 2, 1895	A. P. Davis	9.5	525	Do.
Dec. 23, 1897	J. B. Lippincott	4.9	522	Do.

Estimated monthly discharge of King River at Slate Point, Fresno County.[a]

[Drainage area, 1,742 square miles.]

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1878.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
November	300	17,851	0.17	0.19
December	290	17,831	.17	.20
1879.				
January	370	22,750	.21	.24
February	870	48,317	.50	.52
March	1,970	121,131	1.13	1.30
April	4,750	282,645	2.73	3.05
May	5,090	312,972	2.92	3.37
June	3,760	223,736	2.16	2.41
July	1,650	101,455	.95	1.10
August	380	23,365	.22	.25
September	270	16,066	.15	.17
October	280	17,217	.16	.18
November	400	23,802	.23	.26
December	1,440	88,542	.83	.96
The year	1,769	1,281,998	1.02	13.81
1880.				
January	720	44,271	.41	.47
February	1,040	59,821	.60	.65
March	1,120	68,866	.64	.74
April	5,230	311,207	3.00	3.35
May	7,120	437,792	4.09	4.71
June	9,540	567,669	5.48	6.12
July	4,800	295,141	2.76	3.18
August	1,150	70,711	.66	.76
September	370	22,017	.21	.23
October	220	13,527	.13	.15
November	220	13,091	.13	.15
December	510	31,359	.29	.33
The year	2,670	1,935,472	1.53	20.84

[a] Authority, California State engineer.

Estimated monthly discharge of King River, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth
1881.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
January	870	53,494	0.50	0.58
February	2,430	134,955	1.39	1.45
March	1,900	116,826	1.09	1.26
April	5,800	345,124	3.33	3.71
May	8,220	505,428	4.72	5.44
June	5,010	298,116	2.88	3.21
July	4,790	294,526	2.75	3.17
August	650	39,967	.37	.43
September	340	20,231	.20	.22
October	250	15,372	.14	.16
November	230	13,686	.13	.15
December	260	15,987	.15	.17
The year	2,562	1,853,712	1.47	19.95
1882.				
January	380	23,365	.22	.25
February	440	24,436	.25	.28
March	1,250	76,859	.72	.83
April	3,170	188,628	1.82	2.03
May	9,190	565,071	5.28	6.08
June	6,410	381,421	3.68	4.11
July	2,020	124,205	1.16	1.34
August	620	38,122	.36	.41
September	390	23,207	.22	.25
October	610	37,507	.35	.40
November	470	27,967	.27	.30
December	340	20,906	.20	.23
The year	2,107	1,531,694	1.21	16.48

Estimated monthly discharge of King River, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1883.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	320	19,676	0.18	0.21
February	340	18,883	.20	.21
March	1,050	64,562	.60	.69
April	2,220	132,099	1.27	1.42
May	6,700	411,967	3.85	4.44
June	6,730	400,463	3.86	4.31
July	1,460	89,772	.84	.97
August	600	36,893	.34	.39
September	480	28,562	.28	.31
October	420	25,825	.24	.28
November	260	15,471	.15	.17
December	220	13,527	.13	.15
The year	1,733	1,257,700	.99	13.55
1884.				
January	430	26,440	.25	.29
February	2,620	150,704	1.50	1.62
March	3,610	221,970	2.07	2.39
April	3,370	200,529	1.93	2.15
May	9,210	566,301	5.29	6.09
June	17,630	1,049,058	10.12	11.29
July	13,210	812,251	7.58	8.74
August	3,570	219,511	2.05	2.36
September	880	52,364	.51	.57
October	900	55,339	.52	.60

Estimated monthly discharge of King River at Red Mountain, Fresno County.[a]

[Drainage area, 1,742 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1895.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
September	3,920	360	778	46,294	0.45	0.5
October	520	320	371	22,812	.21	.24
November	1,834	250	368	21,898	.21	.3
December	520	250	328	20,168	.19	.2
The year	3,920	250	461	111,172	.27	1.3
1896.						
January	11,020	390	1,474.8	90,682	.85	.9
February	1,140	728	825.4	47,477	.47	.5
March	7,020	820	1,710.6	105,181	.98	1.1
April	4,600	390	1,938.5	115,349	1.11	1.2
May	22,100	1,140	5,918.1	363,890	3.40	3.9
June	18,920	5,160	12,737.3	757,922	7.31	8.1
July	6,680	1,212	3,742.2	230,110	2.15	2.4
August	1,212	590	795.9	48,938	.45	.5
September	590	390	491.3	29,234	.28	.3
October	510	310	350	21,520	.20	.2
November	1,076	390	538.5	32,043	.31	.3
December	550	470	498.4	30,645	.29	.3
The year	22,100	310	2,585.1	1,872,991	1.48	20.1
1897.						
January	624	360	437	26,870	.25	.2
February	6,344	1,100	1,631	90,581	.92	.9
March	4,408	1,240	1,884	115,843	1.06	1.2
April	9,380	1,930	5,318	316,442	2.99	3.3
May	22,732	6,344	14,470	889,731	8.15	9.4
June	10,580	2,520	6,145	365,652	3.45	3.8
July	4,040	1,036	2,177	133,859	1.22	1.4
August	1,100	440	739	45,440	.42	.4
September	480	250	329	19,577	.18	.2
October	572	270	394	24,226	.22	.2
November	2,520	360	692	41,177	.39	.4
December	8,348	572	985	60,566	.55	.6
The year	22,732	250	2,933	2,129,964	1.65	22.4

[a] Authority, United States Geological Survey.

Estimated monthly discharge of King River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1898.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	624	440	506	31,113	0.29	0.33
February	1,170	480	705	39,154	.40	.41
March	1,170	520	895	55,032	.50	.58
April	7,820	1,036	3,547	211,061	2.00	2.23
May	6,520	2,450	3,536	217,422	1.99	2.29
June	3,280	1,310	2,122	126,267	1.20	1.34
July	1,310	440	696	42,796	.39	.45
August	400	215	320	19,676	.18	.21
September	780	145	204	12,139	.12	.13
October	728	215	320	19,676	.18	.21
November	285	215	231	13,745	.13	.14
December	1,450	180	315	19,369	.18	.21
The year	7,820	145	1,116	807,450	.63	8.53
1899.						
January	1,310	250	513	31,543	.29	.33
February	1,036	440	660	36,655	.37	.39
March	20,200	624	2,165	133,121	1.22	1.41
April	7,300	1,834	4,512	268,483	2.54	2.83
May	4,780	1,450	3,568	219,388	2.01	2.32
June	10,300	2,852	6,077	361,607	3.42	3.81
July	2,852	676	1,411	86,759	.79	.91
August	624	250	411	25,271	.23	.26
September	285	180	215	12,793	.12	.13
October	1,205	180	378	23,242	.21	.24
November	1,240	345	638	37,964	.36	.40
December	5,096	400	991	60,934	.56	.64
The year	20,200	180	1,795	1,297,760	1.01	13.67

Estimated monthly discharge of King River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1900.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet*	*Inches*
January	12,700	849	1,689	103,853	0.97	1.12
February	849	676	748	41,542	.43	.45
March	2,584	728	1,712	105,267	.98	1.13
April	2,852	1,546	2,098	124,840	1.20	1.34
May	9,400	1,930	5,881	361,609	3.38	3.90
June	7,900	2,986	5,127	305,078	2.94	3.27
July	2,584	572	1,278	78,581	.73	.84
August	624	250	398	24,472	.23	.26
September	520	215	301	17,911	.17	.19
October	440	215	309	19,000	.18	.21
November	15,700	250	1,310	77,950	.75	.83
December	972	572	726	44,640	.42	.48
The year	15,700	215	1,798	1,304,743	1.03	14.02
1901.						
January	43,930	520	4,337	266,672	2.49	2.87
February	7,040	1,040	3,319	190,392	1.90	2.10
March	4,490	2,034	2,965	182,311	1.70	1.96
April	10,840	1,642	4,492	267,293	2.58	2.87
May	21,830	5,548	11,093	682,082	6.37	7.36
June	21,180	7,040	14,363	854,658	8.25	9.20
July	13,240	3,280	6,258	384,789	3.59	4.14
August	6,260	728	2,292	140,930	1.32	1.52
September	780	440	534	31,775	.31	.35
October	2,034	360	535	32,896	.31	.36
November	1,450	480	694	41,296	.40	.45
December	1,170	440	668	41,073	.38	.44
The year	43,930	360	4,296	3,116,167	2.47	33.52

Estimated monthly discharge of King River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1902.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	520	360	440	27,055	0.25	0.29
February	2,852	360	665	36,932	.38	.40
March	4,490	1,040	1,422	87,312	.82	.95
April	26,380	1,450	4,163	247,716	2.39	2.67
May	13,760	3,440	6,532	401,637	3.75	4.32
June	13,240	3,760	8,063	479,782	4.63	5.16
July	3,600	1,040	1,638	100,717	.94	1.08
August	910	320	626	38,491	.36	.42
September	360	250	304	18,089	.17	.19
October	520	215	265	16,294	.15	.17
November	1,170	250	451	26,836	.26	.29
December	1,040	400	497	30,559	.29	.33
The year	26,380	215	2,089	1,511,420	1.20	16.27

LITTLE ROCK CREEK.

Discharge measurements of Little Rock Creek, Los Angeles County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
June 2, 1896	J. B. Lippincott	2	Head works Little Rock irrigation district.
Apr. 20, 1896	J. A. Vogelson	7.2	Head works South Antelope Valley Water Company.
June 2, 1896	J. B. Lippincott	1	Do.
Feb. 9, 1897	do	21.3	Do.
Apr. 7, 1897	do	120	Do.
Jan. 5, 1898	do	3	Do.
July 19, 1900	B. Cole	1.4	Pumped water in ciénaga.

LOBETUS CREEK.

Discharge measurement of Lobetus Creek, San Mateo County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Oct. 17, 1893	W. W. Brier	0.18	1 mile above mouth.

LOGSDON AND FARREL DITCH, SAN BERNARDINO COUNTY.

See San Bernardino Valley, Logsdon and Farrel ditch.

LOMA ABAJO.

The Loma Abajo was measured by Charles J. Johansen for the Pacific Improvement Company, as indicated below. The point of measurement was a short distance above the junction with the Gato. At the time of these measurements no water was flowing in the pipe line from the Loma Abajo to the Ontare ranch.

List of discharge measurements of Loma Abajo River in Santa Barbara County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Feb. 7, 1890	Charles J. Johansen	3.84	Above junction with Gato.
Feb. 14, 1890	do	3.00	Do.
Feb. 27, 1890	do	5.67	Do.
Mar. 2, 1890	do	3.21	Do.
Mar. 4, 1890	do	3.00	Do.
Mar. 6, 1890	do	2.80	Do.
Mar. 9, 1890	do	2.80	Do.
Mar. 11, 1890	do	2.24	Do.
Mar. 13, 1890	do	2.06	Do.
Mar. 15, 1890	do	2.06	Do.
Mar. 17, 1890	do	1.88	Do.
Mar. 21, 1890	do	1.88	Do.
Mar. 23, 1890	do	1.88	Do.
Mar. 25, 1890	do	1.55	Do.
Mar. 27, 1890	do	1.55	Do.
Mar. 29, 1890	do	1.55	Do.
Mar. 31, 1890	do	1.39	Do.
Apr. 2, 1890	do	1.39	Do.
Apr. 4, 1890	do	1.39	Do.
Apr. 6, 1890	do	1.23	Do.
Apr. 8, 1890	do	1.23	Do.
Apr. 10, 1890	do	1.08	Do.
Apr. 12, 1890	do	1.23	Do.
Apr. 14, 1890	do	1.08	Do.
Apr. 17, 1890	do	.92	Do.
Apr. 18, 1890	do	.76	Do.
Apr. 20, 1890	do	.76	Do.
Apr. 22, 1890	do	.76	Do.
Apr. 24, 1890	do	.76	Do.
Apr. 26, 1890	do	.76	Do.

List of discharge measurements of Loma Abajo River, etc.—Continued.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Apr. 28, 1890	Charles J. Johansen	0.76	Above junction with Gato.
Apr. 30, 1890	do	.76	Do.
May 2, 1890	do	.76	Do.
May 4, 1890	do	.68	Do.
May 6, 1890	do	.68	Do.
May 8, 1890	do	.60	Do.
May 10, 1890	do	.60	Do.
May 12, 1890	do	.60	Do.
May 14, 1890	do	.46	Do.
May 16, 1890	do	.60	Do.
May 18, 1890	do	.53	Do.
May 20, 1890	do	.53	Do.
May 20, 1890	do	.74	Do.
May 22, 1890	do	.59	Do.
May 24, 1890	do	.59	Do.
May 26, 1890	do	.61	Do.
May 28, 1890	do	.61	Do.
May 30, 1890	do	.59	Do.
June 1, 1890	do	.58	Do.
June 3, 1890	do	.49	Do.
June 5, 1890	do	.49	Do.
June 7, 1890	do	.44	Do.
June 9, 1890	do	.47	Do.
June 11, 1890	do	.47	Do.
June 13, 1890	do	.42	Do.
June 15, 1890	do	.50	Do.
June 17, 1890	do	.56	Do.
June 19, 1890	do	.52	Do.
June 21, 1890	do	.49	Do.
June 23, 1890	do	.42	Do.
June 25, 1890	do	.45	Do.
June 27, 1890	do	.42	Do.
June 29, 1890	do	.37	Do.
July 1, 1890	do	.34	Do.
July 3, 1890	do	.42	Do.
July 5, 1890	do	.26	Do.
July 7, 1890	do	.24	Do.
July 9, 1890	do	.23	Do.
July 11, 1890	do	.24	Do.
July 13, 1890	do	.24	Do.

List of discharge measurements of Loma Abajo River, etc.—Continued.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
July 15, 1890	Charles J. Johansen	0.24	Above junction with Gate
July 17, 1890	do	.20	Do.
July 19, 1890	do	.23	Do.
July 21, 1890	do	.17	Do.
July 23, 1890	do	.20	Do.
July 25, 1890	do	.18	Do.
July 27, 1890	do	.21	Do.
July 29, 1890	do	.21	Do.
July 31, 1890	do	.23	Do.
Aug. 2, 1890	do	.24	Do.
Aug. 4, 1890	do	.26	Do.
Aug. 6, 1890	do	.20	Do.
Aug. 8, 1890	do	.18	Do.
Aug. 10, 1890	do	.24	Do.
Aug. 12, 1890	do	.27	Do.
Aug. 14, 1890	do	.30	Do.
Aug. 17, 1890	do	.12	Do.
Aug. 19, 1890	do	.13	Do.
Aug. 21, 1890	do	.17	Do.
Aug. 23, 1890	do	.11	Do.
Aug. 25, 1890	do	.12	Do.
Aug. 27, 1890	do	.12	Do.
Aug. 29, 1890	do	.11	Do.
Aug. 31, 1890	do	.09	Do.
Sept. 2, 1890	do	.07	Do.
Sept. 4, 1890	do	.08	Do.
Sept. 6, 1890	do	.12	Do.
Sept. 8, 1890	do	.06	Do.
Sept. 10, 1890	do	.09	Do.
Sept. 12, 1890	do	.07	Do.
Sept. 14, 1890	do	.09	Do.
Sept. 16, 1890	do	.09	Do.
Sept. 18, 1890	do	.11	Do.
Sept. 20, 1890	do	.08	Do.
Sept. 22, 1890	do	.09	Do.
Sept. 24, 1890	do	.12	Do.
Sept. 26, 1890	do	.13	Do.
Sept. 28, 1890	do	.14	Do.
Sept. 30, 1890	do	.30	Do.
Oct. 2, 1890	do	.20	Do.

List of discharge measurements of Loma Abajo River, etc.—Continued.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Oct. 4, 1890	Charles J. Johansen	0.14	Above junction with Gato.
Oct. 6, 1890	do	.14	Do.
Aug. 18, 1890, a. m	do	.07	Below Upper Forks.
Aug. 18, 1890, p. m	do	.04	Do.
Aug. 21, 1890, a. m	do	.11	Do.
Aug. 21, 1890, p. m	do	.04	Do.
May 21, 1890	do	.46	Upper Forks—East Fork.
Do	do	.07	Upper Forks—West Fork.
June 4, 1890	do	.31	Upper Forks—East Fork.
Do	do	.06	Upper Forks—West Fork.

LOPEZ CREEK.

Discharge measurements of Lopez Creek, San Luis Obispo County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Nov. 19, 1897	W. W. Brier	5.51	10 miles above Arroyo Grande.

LOS ANGELES RIVER.

Los Angeles River heads immediately south of Santa Clara River, its various tributaries receiving their supply from the mountains surrounding the San Fernando Plains. It passes out of the lower end of the plain through a narrow valley known as The Narrows, at the lower end of which is the city of Los Angeles. The streams entering San Fernando Valley have brought down immense quantities of sand and gravel from the mountainous area, and thus have formed the San Fernando Plains. This coarse deposit acts as a natural regulator, absorbing the flood waters, which gradually appear lower down. The rainfall of Southern California has been deficient for the last few years, but the discharge of Los Angeles River at The Narrows has been exceptionally constant, the decrease in 1900 being not more than 20 per cent of the average. On account of the numerous lawsuits which have arisen regarding water rights on this river, a thorough study of its discharge has been instituted by the city of Los Angeles, the work being under the direction of J. B. Lippincott, as consulting

engineer for the city. The majority of the measurements have been made by C. A. Miller, although a number of them were made by F. H. Olmsted, city engineer. Several weirs have been placed in the river where the measurements are made. The points of measurement are as follows, in order downstream:

Weir A, at the intersection of Pacoima avenue with Los Angeles River, in the Lankershim Rancho subdivision.

Weir B, at the intersection of Vineland avenue with Los Angeles River.

Weir C, at the intersection of Fernando avenue with Los Angeles River.

Weir E, at the southwest corner of block 73, Providencia Rancho.

Weir G, at the intersection of the east line of block 71, Providencia Rancho, with Los Angeles River.

Weir L, 770 feet above weir H.

Weir H, approximately 300 feet east of the intersection of Buena Vista street with Los Angeles River.

Weir I, 2,543 feet below weir H.

Weir J, 600 feet east of the west line of block 69, Providencia Rancho.

Weir K, in block 79, Providencia Rancho, 300 feet west of center.

Measuring bridge P, near the southwest corner of block 81, Providencia Rancho, in the headworks site of the city of Los Angeles, commonly known as the Potrero & Hooker tract, where river turns to the east at angle of 90°.

Measuring bridge Q, about 400 feet above the junction of the Verdugo Wash with Los Angeles River.

Measuring bridge No. 2, about 600 feet above the head of the power ditch of the Los Angeles City Water Company, in the so-called Crystal Springs tract.

Weir No. 7, 1 mile below the head, in the main supply ditch, sometimes called the Woolen Mill ditch, in the headworks site.

Measuring point No. 7B, at a 3-foot cement pipe in the same ditch, west of bridge No. 2 and at the Los Felix ranch house.

Weir No. 17, opposite bridge No. 2, on what is called the Glassell tributary.

To get the total flow of river at bridge No. 2, there should be combined the flow at bridge No. 2, weir No. 17, and measuring point No. 7B. In case measurements were not taken on the main supply ditch at No. 7B, the measurement observed at weir No. 7, above No. 7B on the main supply ditch, was used, and the loss between No. 7 and No. 7B, 2.49 second-feet, was deducted. This is shown in detail in the table for bridge No. 2. For bridge Q a similar process is followed, omitting No. 17. For bridge P the observed flow at the bridge is combined with either the flow at No. 7 or at No. 7B.

Weir No. 9, at the mouth of Tujunga Creek, near the western end of the headworks site, and near the intersection of Buena Vista street with Los Angeles River.

Weir No. 10, approximately 200 feet west of weir No. 9, at the outlet of a small cut which was run into the gravel bed for the development of water.

Weir M, block 67, Providencia Rancho, on a small stream entering the river in the headworks tract.

Discharge measurements of Los Angeles River.

AT WEIR A.

Date.	Discharge.	Average for month.	Date.	Discharge.	Average for month.
1899.	*Sec.-feet.*	*Sec.-feet.*	1900.	*Sec.-feet.*	*Sec.-feet.*
August 14	0.565	0.612	May 17	0.461	0.461
August 19	.660		June 12	.461	.431
September 20	.500	.500	June 29	.402	
September 26	.500		August 1	.310	.370
October 24	.687	.687	August 8	.368	
November 24	.725	.723	August 15	.372	
November 28	.721		August 31	.430	
December 7	.678	.723	September 8	.378	.368
December 28	.768		September 11	.400	
			September 27	.328	
			November 10	.380	.380
Mean		.649	Mean		.402

AT WEIR B.

1899.			1900.		
August 14	0.500	0.500	May 17	0.482	0.482
September 20	.500	.500	June 12	.430	.355
September 26	.500		June 29	.280	
October 24	.755	.755	July 27	.160	.160
November 24	.937	.939	August 1	.180	.198
November 28	.941		August 15	.197	
December 7	.864	.923	August 31	.219	
December 28	.982		September 8	.209	.203
			September 11	.223	
			September 27	.176	
			November 10	.260	.260
Mean		.723	Mean		.276

Discharge measurements of Los Angeles River—Continued.

AT WEIR C.

Date.	Discharge.	Average for month.	Date.	Discharge.	Average for month.
1899.	*Sec.-feet.*	*Sec.-feet.*	1900.	*Sec.-feet.*	*Sec.-feet.*
August 14	2.88	2.88	May 17	2.98	2.98
August 28	2.88		June 12	2.91	2.91
September 20	2.69	2.48	July 27	2.45	2.45
September 26	2.26		August 1	2.50	2.50
October 9	2.88	2.93	August 8	2.48	
October 24	2.98		August 15	2.48	
November 24	3.45	3.43	August 31	2.55	
November 28	3.42		September 8	1.58	
December 28	3.44	3.44	September 11	2.38	1.86
			September 27	1.63	
			November 10	2.42	2.42
Mean		3.03	Mean		2.52

AT WEIR E.

1899.			1900.		
August 14	5.55	5.55	May 15	5.45	5.45
August 28	5.55		June 12	5.18	4.99
September 20	5.35	5.30	June 29	4.81	
September 26	5.25		July 12	4.80	4.80
October 25	5.99	5.99	July 27	4.80	
November 17	6.53	6.38	August 1	4.53	
November 28	6.24		August 15	4.47	4.66
December 13	6.24		August 31	4.88	
December 21	6.24	6.26	September 8	4.49	
December 26	6.30		September 11	4.65	4.49
			September 27	4.30	
			November 10	4.67	4.67
Mean		5.89	Mean		4.84

Discharge measurements of Los Angeles River—Continued.

AT WEIR G.

Date.	Discharge.	Average for month.	Date.	Discharge.	Average for month.
1899.	*Sec.-feet.*	*Sec.-feet.*	1900.	*Sec.-feet.*	*Sec.-feet.*
August 14	7.92	7.92	May 15	7.94	7.94
August 28	7.92		June 12	7.63	7.31
September 20	7.60	7.60	June 29	7.00	
September 26	7.60		July 27	6.45	6.45
October 9	7.66	8.13	August 1	6.45	6.70
October 25	8.60		August 15	6.80	
November 17	9.17	9.08	August 31	6.87	
November 28	8.99		September 8	6.72	6.80
December 13	8.90	8.90	September 11	7.00	
December 21	8.90		September 27	6.68	
December 26	8.92		November 13	6.99	6.99
Mean		8.33	Mean		7.03

AT WEIR L.

1899.			1900.		
August 14	9.08	9.00	May 15	8.85	8.79
August 28	8.93		May 23	8.73	
September 20	8.59	8.74	June 12	8.62	8.46
September 26	8.89		June 29	8.30	
October 9	8.59	9.23	July 27	7.53	7.53
October 25	9.58		August 1	7.53	7.71
October 27	9.48		August 8	7.59	
November 17	10.15	10.04	August 15	7.69	
November 28	9.93		August 31	8.02	
December 13	10.02	10.11	September 8	7.82	7.92
December 21	10.02		September 11	8.20	
December 26	10.30		September 27	7.76	
			November 10	8.34	8.34
Mean		9.42	Mean		8.12

Discharge measurements of Los Angeles River—Continued.

AT WEIR H.

Date.	Discharge.	Average for month.	Date.	Discharge.	Average for month.
1899.	*Sec.-feet.*	*Sec.-feet.*	1900.	*Sec.-feet.*	*Sec.-feet.*
August 14	11.88	12.04	May 15	11.42	11.31
August 28	12.19		May 23	11.21	
September 20	11.60	11.82	June 12	11.01	10.84
September 26	12.03		June 29	10.68	
October 9	11.60	12.31	July 27	9.96	9.96
October 25	12.66		August 1	9.96	10.29
October 27	12.66		August 8	10.16	
November 17	13.73	13.60	August 15	10.13	
November 28	13.47		August 31	10.57	
December 13	13.42	13.62	September 8	10.15	10.19
December 21	13.64		September 11	10.39	
December 26	13.80		September 27	10.03	
			November 10	10.54	10.54
Mean		12.68	Mean		10.51

AT WEIR I.

1899.			1900.		
August 14	17.18	17.04	May 15	16.25	16.15
August 28	16.91		May 23	16.05	
September 20	17.15	17.23	June 12	15.66	15.57
September 26	17.32		June 29	15.49	
October 9	17.19	17.76	July 12	15.58	15.28
October 25	18.33		July 27	14.74	
November 17	19.04	18.88	August 1	14.37	14.70
November 28	18.72		August 8	14.94	
December 13	18.93	18.96	August 15	14.69	
December 26	18.99		August 31	14.80	
			September 8	14.54	14.54
			September 11	14.74	
			September 27	14.31	
			November 10	14.92	14.92
Mean		17.97	Mean		15.17

Discharge measurements of Los Angeles River—Continued.

AT WEIR J.

NOTE.—Total discharge of river at weir J equals discharge over weir + discharge at No. 7, or + No. 7B + 2.49.

Date.	Discharge at No. 7, or No. 7B+2.49.	Discharge over weir.	Total discharge for weir.	Average for month.
1899.	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Second-feet.*
August 14	18.59	0.55	19.14	18.76
August 28	17.90	.49	18.39	
September 20	17.90	.49	18.39	18.58
September 26	18.28	.49	18.77	
October 9	18.08	.44	18.52	18.91
October 25	17.45	1.85	19.30	
November 17	18.02	2.91	20.93	20.71
November 28	13.78	6.71	20.49	
December 13	13.90	6.34	20.24	20.31
December 26	13.66	6.73	20.39	
Mean				19.45
1900.				
May 15	20.09	1.39	21.48	19.76
May 23	16.37	1.67	18.04	
June 12	19.81	.86	20.67	18.92
June 29	16.31	.86	17.17	
August 15	18.49	.41	18.90	19.31
August 31	19.25	.43	19.71	
September 8		.42		
September 11	19.81	.52	20.33	19.15
September 27	17.59	.39	17.98	
November 10	14.84	1.49	16.33	16.33
Mean				18.69

Discharge measurements of Los Angeles River—Continued.

AT WEIR K.

NOTE.—Total discharge of river at weir K equals discharge over weir + discharge at No. 7 + No. 7B + 2.49.

Date.	Discharge at No. 7, or No. 7B+2.49.	Discharge over weir.	Total discharge for weir.	Average for month.
1899.	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Second-feet.*
August 14	18.59	4.13	22.72	22.5
August 28	17.90	3.92	21.82	
September 20	17.90	3.91	21.81	22.0
September 26	18.28	3.98	22.26	
October 9	18.08	4.13	22.21	22.6
October 25	17.45	5.70	23.15	
November 17	18.02	6.97	24.99	24.7
November 28	13.78	10.69	24.47	
December 13	13.90	10.69	24.59	24.5
December 26	13.66	10.92	24.58	
Mean				23.5
1900.				
May 15	20.09	4.94	25.03	23.2
May 23	16.37	4.94	21.31	
July 2	16.32	2.93	19.25	19.3
August 1		2.55		
August 15	18.49	2.71	21.20	21.5
August 31	19.25	2.55	21.80	
September 8		2.81		
September 11	19.81	2.80	22.61	21.3
September 27	17.59	2.50	20.09	
November 10	14.84	4.12	18.96	18.9
Mean				21.7

Discharge measurements of Los Angeles River—Continued.

AT BRIDGE P.

NOTE.—Total discharge of river at bridge P equals discharge at bridge + discharge at No. 7, or + discharge at No. 7B.

Date.	Discharge at No. 7 or No. 7B.	Discharge at bridge.	Total discharge at bridge.	Average for month.
1899.	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Sec.-feet.*
August 25	18.66	20.22	38.88	38.88
September 20	17.90	19.36	37.26	38.50
September 27	18.66	21.08	39.74	
October 10	18.08	19.81	37.89	37.16
October 25	17.45	17.62	35.07	
October 28	17.45	21.06	38.51	
November 17	18.02	25.73	43.75	42.34
November 28	13.18	27.75	40.93	
December 13	13.90	31.94	45.84	43.58
December 26	13.66	27.67	41.33	
Mean				40.09
1900.				
May 15	17.60	21.22	38.82	36.49
May 23	13.88	20.28	34.16	
June 12	17.32	18.59	35.91	35.91
July 2	13.83	19.51	33.34	32.16
July 12	14.00	16.99	30.99	
August 1	14.00	17.04	31.04	33.23
August 8	14.00	18.71	32.71	
August 15	16.00	19.94	35.94	
September 8		19.26		
September 11	17.32	19.67	36.99	35.23
September 28	15.10	18.38	33.48	
Mean				34.60

Discharge measurements of Los Angeles River—Continued.

AT BRIDGE Q.

NOTE. Total discharge of river at bridge Q equals discharge at Q + discharge at No. 7-2.49 or + No. 7B.

Date.	Discharge at No. 7-2.49, or 7B.	Discharge at bridge.	Total discharge at bridge.	Average for month.
1899.	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Second-feet.*
September 20	15.41	28.12	43.53	45.84
September 27	16.17	27.99	44.16	
October 10	15.59	27.77	43.36	41.62
October 25	8.21	27.66	35.87	
October 28	8.23	36.48	44.71	
November 17	9.36	39.71	49.07	47.58
November 29	12.20	33.89	46.09	
December 13	11.41	35.99	47.40	45.21
December 26	11.17	31.86	43.03	
Mean				44.49
1900.				
May 15	17.60	28.42	46.02	43.94
May 23	13.88	27.97	41.85	
June 12	17.32	27.64	44.96	44.96
July 2	13.83	26.20	40.03	39.41
July 12	14.00	24.79	38.79	
August 1	14.00	24.48	38.48	38.48
September 8		27.09		
September 11	17.32	26.22	43.54	43.96
September 28	15.10	29.33	44.43	
Mean				42

Discharge measurements of Los Angeles River, Los Angeles County, near bridge No. 2.

Date.	Hydrographer	Discharge.	Locality.
		Sec.-feet.	
June 15, 1889	Wm. Mulholland	36.7	River.
Do	do	11.1	Power ditch.
Do	do	11.2	Main supply ditch.
	Total flow at bridge 2.	59.0	
July 15, 1889	Wm. Mulholland	33.3	River.
Do	do	11.0	Power ditch.
Do	do	14.1	Main supply ditch.
	Total at bridge 2	58.4	
Nov. 18, 1891	Wm. Mulholland	68.0	River.
Do	do	10.0	Power ditch.
Do	do	3.0	Main supply ditch.
	Total at bridge 2	81.0	
Nov. —, 1893	Wm. Mulholland	58.8	River.
Do	do	15.0	Power ditch.
Do	do	(?)	Main supply ditch.
Feb. 28, 1898	do	51.8	River.
Do	do	.7	Glassell tributary.
Do	do	15.0	Main supply ditch.
Do	do	.....	Power ditch, measurement above.
	Total at bridge 2	67.5	

Discharge measurements of Los Angeles River at bridge No. 2.

NOTE.- Total discharge of river at bridge No. 2 equals discharge at No. 2 + discharge at No. 7B, or No. 2 + No. 7 - 2.49.

Date.	Discharge at No. 7—2.49, or No. 7B.	Discharge at No. 17.	Discharge at bridge.	Total discharge at bridge.	Average for month.
1899.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*
August 19	15.59	0.06	41.29	56.94	57.79
August 25	16.17	.06	42.41	58.64	
September 20	15.41	.06	40.23	55.70	56.10
September 27	16.17	.06	40.07	56.30	
October 10	15.59	.05	39.35	54.99	55.61
October 25	8.21	.05	48.88	57.14	
October 28	8.23	.05	44.45	52.73	
October 31	8.78	.05	48.73	57.56	
November 17	9.36	.06	49.71	59.13	57.39
November 29	12.20	.06	43.40	55.66	
December 13	11.41	.07	46.69	58.17	58.15
December 26	11.17	.07	46.89	58.13	
Mean					56.99
1900.					
May 16	17.60	.14	39.61	57.35	54.91
May 23	13.88	.14	38.46	52.48	
June 12	17.32	.14	39.23	56.69	56.69
July 2	13.83	.10	35.38	49.31	52.42
July 13	15.32	.14	40.10	55.56	
August 1	14.00	.10	34.62	48.72	51.12
August 8	14.00	.10	34.77	48.87	
August 15	16.00	.10	38.58	54.68	
August 31	16.76	.10	35.36	52.22	
September 8			34.27		
September 11	17.32	.20	35.56	53.08	51.27
September 28	15.10	.08	34.28	49.46	
November 10	14.84	.10	39.45	54.39	54.39
Mean					53.46

Average discharge of Los Angeles River at weir No. 9.

Month.	1899.	1900.	Month.	1899.	1900.
	Sec.-feet.	*Sec.-feet.*		*Sec.-feet.*	*Sec.-feet.*
January	1.17	0.52	July	0.55	0.15
February	1.00	.49	August	.48	.18
March	1.16	.39	September	.44	.20
April	1.10	.38	October	.64	
May	.71	.30	November	.56	
June	.69	.24	December	.52	

Average discharge of developed water at weir No. 10.

Month.	1899.	1900.	Month.	1899.	1900.
	Sec.-feet.	*Sec.-feet.*		*Sec.-feet.*	*Sec.-feet.*
January		0.89	July	0.79	0.74
February		.81	August	.79	.73
March	0.96	.86	September	.83	.70
April	.93	.79	October	.86	
May	.90	.82	November	.94	
June	.86	.79	December	.91	

Average discharge of small tributary of Los Angeles River at weir M.

Month	Discharge.	Month.	Discharge.
1899.	*Sec.-feet.*	1899.	*Sec.-feet.*
January	0.29	July	Dry.
February	.20	August	Do.
March	.20	September	Do.
April	.14	October	Do.
May	.07	November	Do.
June	.06	December	Do.

Average discharge of cut of West Los Angeles Water Company in San Fernando Valley, from gravel beds of Los Angeles River.

Month.	1899.	1900.	Month.	1899.	1900.
	Sec.-feet.	*Sec.-feet.*		*Sec.-feet.*	*Sec.-feet.*
May		5.79	September	6.02	
June		5.85	October	5.94	
July		5.75	November	6.07	
August	6.01	5.87	December	6.08	

Average discharge of Los Angeles River.

Measuring point.	Intervening distance along river.	Average discharge, August to December, inclusive, 1899.	Rate of growth per 100 feet, 1899.	Average discharge May to November, inclusive, 1900.	Rate of growth per 100 feet, 190
	Feet.	*Sec.-feet.*		*Sec.-feet.*	
Weir A		0.649		0.402	
	10,280		0.001		0.0
Weir B		.723		.276	
	3,486		.066		.06
Weir C		3.03		2.52	
	7,069		.039		.03
Weir E		5.89		4.84	
	4,585		.053		.04
Weir G		8.33		7.03	
	1,041		.105		.10
Weir L		9.42		8.12	
	770		.424		.31
Weir H		12.68		10.51	
	2,543		.210		.18
Weir I		17.97		15.17	
	3,926		.038		.03
Weir J		19.45		18.69	
	3,600		.100		.08
Weir K		23.06		20.85	
	6,345		.268		.23
Bridge P		40.09		34.60	
	4,629		.095		.16
Bridge Q		44.49		42.15	
	6,756		.185		.16
Bridge No. 2		56.99		53.46	

Discharge measurements of Los Angeles River, Los Angeles County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-ft.	
Aug. 21, 1899	S. G. Bennett	0.0	Pacoima, mouth of canyon.
Jan. 9, 1901	L. Mesmer	50.0	Do.
Sept. 20, 1901	S. G. Bennett	0.0	Do.
Aug. 21, 1899	do	.44	Tujunga, Headworks Monte Vista Canal.
Oct. 9, 1900	W. W. Cockins	.19	Do.
Sept. 21, 1901	S. G. Bennett	.22	Do.
Nov. 22, 1900	do	18.7	Tujunga Railroad, main line.
Do	do	.05	Tujunga, 3 miles below above measurement.
Do	do	10.60	Tujunga Railroad, main line, flood marks.
Aug. 21, 1899	do	0.0	Tujunga—little.

Discharge measurements of Los Angeles River at pumping stations in San Fernando Valley.

Year.	Hydrographer.	Discharge.	Remarks.
		Sec.-ft.	
1897	J. B. Lippincott	[a]0.11	Total output, 4 plants.
1898	do	[a].33	Total output, 7 plants.
1899	do	[a].99	Total output, 21 plants.
1900	do	[a]1.77	Total output, 33 plants.

[a] Reduced to continuous flow for summer months.

LOS FLORES CANYON.

Los Flores Canyon is situated on the southern slope of the Sierra Madre, in Los Angeles County. The area of the drainage basin above the line of township 1 north, above which all diversions occur, is 0.35 square mile. The canyon is in granite, largely shattered, with prevailing lines of cleavage extending northwest to southeast, but with other distinct lines bearing northeastward. Below the mouth of the canyon are the beautiful Pasadena Mesa lands. The scarcity of water, coupled with the general desirability of these lands, has caused much "development work" to be done for the purpose of increasing the water supply. Twelve tunnels in all have been run into this granite rock. The experience has been that as the fissures and cracks of the rock are opened a considerable discharge has resulted for a period of a few weeks, after which the flow decreased, and the tunnels would then again be extended or new ones run.

Following is a list of the tunnels, showing their lengths:

	Feet.
Los Flores tunnel:	
No. 1	[illegible]
No. 2	[illegible]
No. 3	[illegible]
No. 4	[illegible]
Mining tunnel	[illegible]
Twaddell tunnel	130
McNally tunnel	430
Los Flores tunnel:	
No. 5	185
No. 6	475
No. 7	200
No. 8	357
Twaddell's Tiptop tunnel	132
Total length	2,172

From the nature of the drainage basin and the data obtained from neighboring streams a reasonable natural run-off from this drainage basin, including flood waters, of from 0.10 to 0.15 second-foot might be expected in average years.

The granite bed rock in the drainage basin is covered with a few feet of coarse, disintegrated, granitic soil, very absorbent of water. Rain falling upon this is rapidly absorbed, and the tunnels show within a few weeks the effect of rainfall. During the years when measurements of the tunnels were made the rainfall was, as a rule, much below normal. In the following discharge measurements all the water which is diverted, both developed and natural flow, is included, but probably a few winter storms occurred that produced greater run-off than the capacity of the diversion pipes, and consequently some of the water must have escaped unmeasured.

The lesson to be drawn from this particular case is that the expenditure of the large amount of money required to construct these tunnels was ill advised, the water supply having been not materially, if at all, increased beyond the normal flow of the canyon prior to the construction of the tunnels. A similar experience is the result of like work in Eaton Canyon, which adjoins the Los Flores to the east.

Discharge measurements of Los Flores Canyon, Los Angeles County.

Date.	Mean discharge.	Remarks.
	Sec.-feet.	
1895	0.18	22 inches of rain.
1896	.10	10 inches of rain.
1897	.12	21 inches of rain.
1898	.08	9 inches of rain.
1899	.10	7 inches of rain.
1900	.09	11 inches of rain.
1901	.09	12 inches of raid.

LYTLE CREEK.

This small stream drains the southern slope of the Sierra Madre and discharges its waters on the plains northwest of San Bernardino. Although it drains a comparatively small area of 52 square miles, at the mouth of the canyon its waters are important for irrigation purposes. Owing to the controversies which have arisen over its diversions, a number of lawsuits for the settlement of the claims have been instituted from time to time. A number of measurements of this stream at the mouth of the canyon from 1892 to 1896, inclusive, are given below. They are copied from court records of proceedings in which the water supply of this creek was involved. These cases were tried in the San Bernardino courts by Judge J. W. McKinley. The measurements were made by A. H. Koebig and G. O. Newman, on weirs, and are believed to be accurate.

Discharge measurements of Lytle Creek at mouth of canyon, San Bernardino County, Cal.

Date.	Discharge.	Date.	Discharge.
1892.	*Second-feet.*	1894.	*Second-feet.*
June 3	35.58	August 19	11.44
September 20	18.70	August 25	12.32
September 30	22.04	October 3	16.20
October 28	20.64	1895.	
November 21	22.04	September 2	56.10
November 27	20.68	September 30	40.78
1893.		1896.	
September 7	49.20	March 3	18.08
September 18	49.20	April 23	19.14
September 25	46.34	April 24	18.60
October 4	45.30	April 25	20.52
1894.		May 3	18.52
June 6	17.96	May 4	17.26
June 8	15.50	May 10	18.16
July 10	13.22	May 25	15.32
July 11	13.22	May 26	12.84
July 25	13.36		

Beginning in 1894, measurements of Lytle Creek were also made by H. D. Sibley, who was zanjero of the Lytle Creek canals at that time. The measurements were usually made because the discharge of the stream was below normal. In the winter and spring only the amount of water needed for irrigation was turned into the ditches, but later in the summer the entire flow was diverted. These measurements also were made over weirs and are believed to be fairly accurate. During 1898 trouble was experienced through miners' taking the water from the natural channel and turning it into dry channels, sluice boxes, weirs, mill races, etc., thereby causing an alleged loss of from 20 to 25 per cent of the total flow of the creek. Only a portion of these latter diversions were returned to the creek. The measurements of Mr. Sibley would not show the full flow of Lytle Creek at all times, and sometimes show less than the full discharge, for the reasons mentioned above. During 1899 the amount of water which was diverted into the main canal was measured daily by the Anglo-American Canaigre Company, at a weir erected near the head of its cement ditch. The volumes given have been occasionally checked by visiting the canal and making meter measurements. It is believed that during 1899 practically all the water of the stream was diverted into the canal.

Discharge, in second-feet, of Lytle Creek main canal above Rialto, San Bernardino County, Cal.

[Drainage area, 52 square miles.]

1894.

Day	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1			15.5					
2								
3		24.1	17.2		10.9		13.5	
4								
5	16.1			10.8				
6		22.6						
7			14.1				11.4	14.5
8	19.9				10.8	13.0		
9								13.7
10								
11	17.8	18.5	14.3	10.8			13.7	
12								
13	21.8			13.4				
14			14.3			13.2		
15								
16	22.6		14.4					
17		19.1						
18			15.0		13.7	11.5	14.5	
19	22.6			14.1				
20								
21			14.8	12.7				
22	24.9				11.9	12.7		12.9
23			14.6					
24		18.2	14.9					
25	25.4						14.2	
26								
27			15.0					
28		16.6						
29								
30								12.5
31				11.7	13.4			

Discharge, in second-feet, of Lytle Creek main canal, etc.—Continued.

1895.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	De
1			54.4						
2									
3							36.9		
4			68.0			51.4			
5									
6									
7								30.5	
8		33.9					31.5		
9									
10						48.8			
11								24.9	
12						50.8			
13									
14									
15									
16					50.4				
17						44.8			
18	26.4	43.8					41.9		
19									
20									
21		57.5					36.5		
22							34.1	24.0	
23	37.4				52.5				
24						47.1			
25									
26					54.4				
27									
28						36.5	34.5		
29									
30									
31							34.5		

June 5 to August 16, ditch broken; no measurements.

Discharge, in second-feet, of Lytle Creek main canal, etc.—Continued.

1896.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1					17.8				13.2			
2				22.2		14.1	11.1					
3												
4												
5	20.0									12.2		
6						11.4			12.2			
7								11.5				
8		19.2					11.1					
9						13.5				11.6		16.0
10						12.5			12.2			
11												
12						11.9		10.5				
13		18.4										
14						12.2	12.2					16.0
15				24.9								
16	21.4				17.1			13.7	10.8			17.0
17			19.8									
18				19.7				11.3				
19									11.8			
20							10.5					
21								12.0				
22												16.0
23								12.5		11.1		
24				22.4				12.5				
25											28.0	
26									11.8	20.0		
27							10.7					
28								13.5				
29		17.5										
30					15.0							24.0
31												

Heavy rains March 1 to 15 and October 26; all water turned out of canal.

Discharge, in second-feet, of Lytle Creek main canal, etc.—Continued.

1897.

Day.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.
1								
2								
3		60.0						
4					36.0			
5								
6			60.0					
7		24.0						
8								
9				50.0	30.0			
10	16.0							
11								
12								10.6
13								
14			60.0					
15								
16	24.0				34.0			
17								
18		80.0						
19				60.0				
20								
21		50.0						
22								
23								
24				50.0				
25	20.0		60.0					
26								
27								
28		56.0	70.0	40.0				
29	28.0							
30								
31								

Heavy rains February 3 and 18, March 28, September 14. Chicala Water Company took charge of station June 1.

Discharge, in second-feet, of Lytle Creek main canal, etc.—Continued.

1898.

Day.	May.	June.	July.	Day.	May.	June.	July.	Day.	May.	June.	July.
1			10.9	12				23			
2				13				24			
3				14				25			
4				15		13.9		26			
5				16				27			
6				17				28	14.6	9.0	
7				18				29			
8				19				30			
9				20		11.5		31			
10				21							
11				22		11.7					

No measurements for January to April, inclusive, and August to December, inclusive.

Discharge, in second-feet, of Lytle Creek main canal, etc.—Continued.

1899.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	11.1	11.8	11.2	9.7	11.2	12.2	6.3	9.4	14.5	10.9	10.5	11.1
2	11.1	12.1	11.1	8.9	10.9	10.4	6.8	10.4	15.1	10.8	10.3	11.3
3	12.1	12.1	11.2	8.5	10.9	9.7	6.4	9.6	16.6	10.8	10.3	11.4
4	11.4	12.4	11.1	12.6	10.5	9.5	6.4	10.7	16.7	10.8	10.6	11.1
5	11.7	12.4	10.8	12.5	10.5	9.4	6.4	12.2	16.0	10.7	10.5	11.3
6	11.6	12.5	10.6	12.1	10.5	9.6	6.4	11.0	16.0	10.6	10.6	11.3
7	11.6	12.6	10.4	11.9	10.5	9.2	6.3	10.8	16.0	10.1	10.6	11.3
8	11.6	12.4	10.4	11.8	10.2	9.0	6.2	11.0	15.9	9.9	9.9	11.4
9	11.6	12.1	10.9	11.7	11.8	.....	6.2	11.0	16.5	10.2	9.9	11.4
10	12.0	11.8	10.6	11.9	9.5	7.2	6.0	8.7	16.1	10.8	10.0	11.3
11	16.1	11.8	10.6	11.7	9.5	7.5	5.9	12.0	16.0	11.7	10.2	11.4
12	13.1	11.8	10.6	11.7	9.2	8.2	6.0	12.0	15.8	[a]72.1	10.5	11.3
13	12.2	11.8	10.7	11.0	9.6	8.1	5.9	12.2	15.3	12.4	10.9	11.2
14	12.0	11.6	10.7	10.6	9.5	7.8	5.9	12.1	15.4	13.5	11.0	11.1
15	11.9	11.5	10.7	10.6	9.8	.....	6.0	12.3	16.0	12.7	11.3	11.2
16	12.0	11.5	15.3	10.7	9.4	7.6	6.0	12.3	15.5	13.0	11.7	12.4
17	12.0	11.5	14.7	10.6	9.4	7.8	5.8	12.2	15.3	13.0	11.5	11.8
18	12.0	11.3	13.7	10.7	9.4	7.9	5.4	12.6	14.3	12.3	12.0	11.8
19	11.9	11.4	12.3	10.2	9.7	7.7	5.6	13.0	15.7	12.0	11.9	11.6
20	11.8	11.3	13.7	10.8	9.8	7.3	5.6	13.0	14.9	11.4	11.8	11.6
21	11.7	11.3	13.1	9.9	9.5	7.5	5.8	12.5	15.2	11.2	12.2	11.4
22	11.8	11.3	12.9	9.9	9.4	7.6	7.2	12.4	16.1	11.6	12.7	11.3
23	11.7	11.3	12.8	10.3	9.4	7.4	8.6	12.4	10.8	11.9	12.1	11.1
24	11.6	11.8	13.2	10.6	9.2	7.1	9.3	12.5	10.4	10.3	12.0	11.1
25	11.6	11.4	14.8	10.5	9.2	7.2	8.9	12.4	10.3	10.7	13.8	10.9
26	11.6	11.4	13.5	10.4	9.0	7.4	9.2	12.6	10.3	11.4	11.7	11.3
27	11.6	11.3	13.4	10.4	9.0	7.3	9.4	12.5	10.5	11.3	11.5	11.3
28	11.6	11.3	13.6	10.4	9.0	7.2	9.5	12.2	10.5	11.1	11.5	11.1
29	11.6	.....	13.6	11.0	9.4	6.7	9.7	12.3	10.6	11.0	11.4	11.3
30	11.6	.....	13.5	11.2	9.3	6.4	9.6	12.2	10.6	11.4	11.2	11.1
31	11.7	.....	13.5	.....	.....	.....	10.0	12.1	.....	11.3	.....	11.4
Mean	11.9	11.7	12.2	10.8	9.8	8.1	7.1	11.8	14.3	13.3	11 2	11.3

[a] Rain in mountains.

The summer of 1898 was one during which the smallest stream flow occurred in southern California of which we have record. The period of smallest summer flow was during the month of September. During this minimum period the Edison Electric Company had certain measurements made on Lytle Creek at half hour intervals, to determine the diurnal fluctuations. The discharge of the stream was as follows:

Discharge measurements of Lytle Creek at Millers Narrows, San Bernardino County.

Date.	Time.	Discharge.	Date.	Time.	Discharge.
		Sec.-feet.			*Sec.-feet.*
Sept. 15, 1898	7 a. m.	9.16	Sept. 15, 1898	10.30 p. m.	8.88
Do	7.30 a. m.	9.16	Do	11 p. m.	8.88
Do	8 a. m.	9.16	Do	11.30 p. m.	8.88
Do	8.30 a. m.	9.16	Do	12 midnight	9
Do	9 a. m.	9.00	Sept. 16, 1898	12.30 a. m.	9
Do	9.30 a. m.	7.94	Do	1 a. m.	9
Do	10 a. m.	8.02	Do	1.30 a. m.	9.16
Do	10.30 a. m.	8.02	Do	2 a. m.	9.16
Do	11 a. m.	8.02	Do	2.30 a. m.	9.16
Do	11.30 a. m.	7.74	Do	3 a. m.	9.16
Do	12 m.	7.46	Do	3.30 a. m.	9.16
Do	12.30 p. m.	7.34	Do	4 a. m.	9.16
Do	1 p. m.	7.20	Do	4.30 a. m.	9.16
Do	1.30 p. m.	7.20	Do	5 a. m.	9.16
Do	2 p. m.	7.20	Do	5.30 a. m.	9.16
Do	2.30 p. m.	7.20	Do	6 a. m.	9.16
Do	3 p. m.	7.06	Do	6.30 a. m.	9.16
Do	3.30 p. m.	7.06		12-hour mean	8.86
Do	4 p. m.	6.94			
Do	4.30 p. m.	7.06	Sept. 16, 1898	7 a. m.	9.28
Do	5 p. m.	7.06	Do	7.30 a. m.	9.28
Do	5.30 p. m.	7.34	Do	8 a. m.	9.16
Do	6 p. m.	7.46	Do	8.30 a. m.	9
Do	6.30 p. m.	7.46	Do	9 a. m.	9
	12-hour mean	7.77	Do	9.30 a. m.	8.02
			Do	10 a. m.	8.02
Sept. 15, 1898	7 p. m.	7.46	Do	10.30 a. m.	7.74
Do	7.30 p. m.	7.74	Do	11 a. m.	7.74
Do	8 p. m.	8.40	Do	11.30 a. m.	7.46
Do	8.30 p. m.	8.58	Do	12 m.	7.20
Do	9 p. m.	8.52	Do	12.30 p. m.	7.20
Do	9.30 p. m.	8.72	Do	1 p. m.	7.06
Do	10 p. m.	8.88	Do	1.30 p. m.	6.94

Discharge measurements of Lytle Creek at Millers Narrows, etc.—Continued.

Date.	Time.	Discharge.	Date.	Time.	Discharge.
		Sec.-feet.			*Sec.-feet.*
Sept. 16, 1898	2 p. m	6.80	Sept. 16, 1898	10.30 p. m	9
Do	2.30 p. m	6.94	Do	11 p. m	9
Do	3 p. m	7.20	Do	11.30 p. m	9
Do	3.30 p. m	7.20	Do	12 midnight	9
Do	4 p. m	7.34	Sept. 17, 1898	12.30 a. m	9.16
Do	4.30 p. m	7.34	Do	1 a. m	9.16
Do	5 p. m	7.46	Do	1.30 a. m	9.16
Do	5.30 p. m	7.46	Do	2 a. m	9.16
Do	6 p. m	7.60	Do	2.30 a. m	9.16
Do	6.30 p. m	7.60	Do	3 a. m	9.16
	12-hour mean	7.75	Do	3.30 a. m	9.16
			Do	4 a. m	9.16
Sept. 16, 1898	7 p. m	8.02	Do	4.30 a. m	9.16
Do	7.30 p. m	8.88	Do	5 a. m	9.28
Do	8 p. m	8.88	Do	5.30 a. m	9.28
Do	8.30 p. m	8.88	Do	6 a. m	9.28
Do	9 p. m	8.88	Do	6.30 a. m	9.28
Do	9.30 p. m	8.88		12-hour mean	9.04
Do	10 p. m	9			

The following measurements were made by the United States Geological Survey:

Discharge measurements of Lytle Creek at mouth of canyon, San Bernardino County.

Date.	Hydrographer.	Discharge.	Date.	Hydrographer.	Discharge.
		Sec.-feet.			*Sec.-feet.*
July 24, 1896	J. H. Quinton	15.7	June 8, 1900	S. G. Bennett	6.2
June 10, 1898	J. B. Lippincott	10.7	Sept. 29, 1900	W. W. Cockins, jr	4.6
Aug. 27, 1898	F. H. Olmsted	10.0	Apr. 4, 1902	S. G. Bennett	19.8
Aug. 29, 1899	S. G. Bennett	12.5	Sept. 5, 1902	W. B. Clapp	5.1

MAMMOTH CREEK.

See Owens River, Mammoth Creek.

MARIA IGNACIA CREEK.

Discharge measurement of Maria Ignacia Creek, Santa Barbara County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Aug. —, 1899	Geo. F. Wright	0.5

MARIPOSA CREEK.

Estimated monthly discharge of Mariposa Creek at base of foothills, Mariposa County.[a]

[Drainage area, 122 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1878.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
November	0	0	0	0	0	0
December	0	0	0	0	0	0
1879.						
January	0	0	0		0	0
February			20	1,111	.16	.17
March			45	2,767	.37	.43
April			43	2,559	.35	.39
May			4	246	.03	.03
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December			15	923	.12	.14
The year			11	7,605	.09	1.16
1880.						
January			20	1,230	.16	.18
February			49	2,819	.40	.43
March			24	1,476	.20	.23
April			24	1,428	.20	.22
May			18	1,107	.15	.17
June			12	714	.10	.11
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December			92	5,657	.75	.86
The year			20	14,431	.16	2.20

[a] Authority, California State engineering department. Estimated from run-off of neighboring streams.

Estimated monthly discharge of Mariposa Creek, etc—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean		Per square mile	Depth
1881.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January			134	8,239	1.10	1.27
February			171	9,497	1.40	1.45
March			38	2,337	.31	.36
April			5	298	.04	.04
May			0	0	0	0
June			0	0	0	0
July			0	0	0	0
August			0	0	0	0
September			0	0	0	0
October			0	0	0	0
November			0	0	0	0
December			0	0	0	0
The year			29	20,371	24	[illegible]
1882.						
January	0	0	0	0	0	0
February			24	1,333	.20	.21
March			74	4,550	.61	.70
April			98	5,831	.80	.89
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
November		0	18	1,071	.15	.17
December			12	738	.10	.11
The year			19	13,523	.15	2.06

Estimated monthly discharge of Mariposa Creek, etc.—Continued.

Month.	Discharge.				Run-off.	
	Maximum.	Minimum.	Mean.	Total discharge.	Per square mile.	Depth.
1883.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January			49	3,013	0.40	0.46
February			24	1,333	.20	.21
March			122	7,501	1.00	1.15
April			73	4,344	.60	.67
May		0	37	2,275	.30	.35
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
The year			25	18,466	.21	2.84
1884.						
January		0	12	738	.10	.12
February			488	28,070	4.00	4.31
March			671	41,258	5.50	6.34
April			488	29,037	4.00	4.46
May			244	15,003	2.00	2.31
June			122	7,259	1.00	1.12
July		0	49	3,013	.40	.46
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0

MAYBERRY CANYON.

Discharge measurements of Mayberry Canyon, Los Angeles County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-ft.	
Oct. 19, 1898	J. B. Lippincott	1.40	Alhambra water—including pumped water.
	do	.24	Mayberry water—including pumped water.
	Total flow of canyon	1.64	
Sept. 23, 1899	J. B. Lippincott	1.38	Alhambra water—including pumped water.

McCLOUD RIVER.

Discharge measurements of McCloud River, Shasta County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-ft.	
Sept. 9, 1901	S. G. Bennett	1,096	One-fourth mile above United States fishery.
Sept. 23, 1902	do	1,272	At Hirze Mountain.
Sept. 24, 1902	Chas. A. Miller	1,325	1 mile above Squaw Creek.
Sept. 26, 1902	do	1,356	United States fishery.
Sept. 24, 1902	do	67	Squaw Creek at bridge above mouth.

McINTYRE DITCH.

See San Bernardino Valley, McIntyre ditch.

McKENZIE DITCH.

See San Bernardino Valley, McKenzie ditch.

MEEKS & DALEY DITCH.

See San Bernardino Valley, Meeks & Daley ditch.

MERCED RIVER.

Merced River above Merced Falls drains approximately 1,090 square miles of the western slopes of the Sierra Nevada. Included in the eastern portion of its drainage area are a large number of high peaks, the highest, Mount Lyell, reaching an elevation of 13,090 feet.

The midsummer flow of this stream is larger in proportion to its drainage area than that of the Tuolumne River, which adjoins it on the north.

In their plunge into the Yosemite Valley the waters of the Merced River and its tributaries form most beautiful waterfalls.

The measurement and record of this stream was undertaken in response to numerous requests from persons interested in mining and irrigation. The midsummer flow of the stream is less than the combined capacity of the irrigation and power canals taking water in the vicinity of Snelling. The owners of these canals offered to pay $100 toward the expenses of equipping and maintaining the gaging station for the first year. Mr. H. H. Henderson, county surveyor of Merced County, established a gaging station at a point 1 mile above Merced Falls, April 6, 1901. Meter measurements are made from a cable. The observer is Mr. Charles Siegfeldt.

Discharge measurements of Merced River, Merced County.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
		Feet.	*Sec.-feet.*	
Sept. 11, 1899	S. G. Bennett		35	River, 1 mile above headworks Crocker-Hoffman Canal. [a]
Do	do		5	Old Mill Valley ditch.
Do	do		16.5	Crocker-Hoffman Canal, 300 feet below headworks.
Sept. 10, 1900	do		6.5	Do.
Sept. 4, 1902	L. M. Lawson		37	Crocker-Hoffman Canal, 3 miles below Snelling.
Nov. 27, 1895	J. B. Lippincott		125	Merced Falls.
Sept. 10, 1900	S. G. Bennett		63	Do.
Apr. 6, 1901	do	10.3	1,379	Do.
June 11, 1901	J. B. Lippincott	12	4,139	Do.
Aug. 2, 1901	S. G. Bennett	10.05	1,122	Do.
Aug. 31, 1901	do	8.6	220	Do.
Mar. 6, 1902	do	10.1	1,302	Do.
May 13, 1902	do	12.15	5,413	Do.
Sept. 3, 1902	L. M. Lawson		109	Do.
Sept. 10, 1900	S. G. Bennett		27	Merced River Mills Canal, 2 miles below Snelling.
Do	do		2.1	Snelling ditch.
Aug. 22, 1896	J. B. Lippincott		89	Yosemite Valley, Stoneman House.

[a] Several small ditches are taken out of Merced River above this point.

Discharge measurements of Merced River, Merced County—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
		Feet.	*Sec.-feet.*	
Sept. 25, 1894	N. C. Ray		135	Sec. 6, T. 4 S., R. 17 E., M. D. M.; floats.
Sept. 1–10, 1895	do		680	Sec. 36, T. 3 S., R. 16 E., M. D. M.; floats.
Mar. 25, 1899	do		4,000	Sec. 22, T. 3 S., R. 16 E., M. D. M.; floats.
Sept. 20, 1899	J. H. McKenzie		64	Sec. 6, T. 4 S., R. 17 E., M. D. M.; estimated.
Oct. 20, 1899	N. C. Ray		1,050	Sec. 22, T. 3 S., R. 16 E., M. D. M.; floats.
Sept. 3, 1900	do		55	Flume at Nameless Mining Co.'s dam; all water turned in.
Nov. 22, 1900	do		20,228	Over crest of Nameless Mining Co.'s dam.
Oct. —, 1901	A. Britt		67	Over weir during construction of Mas. C. and M. Co.'s dam.
Sept. 3, 1902	E. T. Perkins		33	150 yards above junction of Illilonette.
Do	do		2.7	Tenaya River, 50 yards above bridge.
Do	do		6.2	Illilonette River, 100 yards above junction of Merced.
Sept. 4, 1902	do		2	Bridal Veil Creek, below bridge in Yosemite Valley.
Do	do		3.2	South Fork at Wawona, below all buildings.
Aug. 30, 1902	L. M. Lawson		76	Benton Mills power flume at Benton Mills.
Aug. 31, 1902	do		97	Horseshoe Bend.
Sept. 1, 1902	do		15	Ditch below power house at Merced Falls.
Do	do		78	1,000 feet below Merced Falls.

Estimated monthly discharge of Merced River at Merced Falls, Merced County.[a]

[Drainage area, 1,076 square miles.]

Month.	Discharge.				Run-off.	
	Maximum.	Minimum.	Mean.	Total discharge.	Per square mile.	Depth.
1879.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January			354	21,767	0.33	0.38
February			1,506	83,639	1.40	1.46
March			2,098	129,001	1.95	2.25
April			3,120	185,653	2.90	3.24
May			3,336	205,123	3.10	3.57
June			3,336	198,506	3.10	3.46
July			968	59,520	.90	1.04
August			172	10,576	.16	.18
September			75	4,463	.07	.08
October			75	4,612	.07	.08
November			173	10,235	.16	.18
December			646	39,721	.60	.69
The year			1,321	952,816	1.23	16.61
1880.						
January			387	23,796	.36	.42
February			753	43,313	.70	.75
March			807	49,621	.75	.86
April			4,250	252,893	3.95	4.41
May			4,842	297,723	4.50	5.19
June			5,111	304,126	4.75	5.30
July			2,744	168,722	2.55	2.94
August			753	46,300	.70	.81
September			323	19,220	.30	.33
October			269	16,540	.25	.29
November			237	14,102	.22	.25
December			1,291	79,380	1.20	1.38
The year			1,814	1,315,736	1.69	22.93

[a] Authority, state engineer, from 1879 to 1884, inclusive. Figures for January, February, and March, 1879, May, June, and July, 1881, November and December, 1882, and the years 1883 and 1884, are estimated from the run-off of neighboring streams. Those from April, 1879, to April, 1881, and from August, 1881, to October, 1882, inclusive, are estimated in part from rod records.

Estimated monthly discharge of Merced River at Merced Falls, etc.—Continued.

Month.	Discharge.				Run-off	
	Maximum.	Minimum	Mean	Total discharge.	Per square mile.	Depth
1881.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet*	*Acre-feet.*	*Sec.-feet.*	*Inches*
January			2,044	125,681	1.90	2.19
February			3,443	191,214	3.20	3.33
March			1,560	95,921	1.45	1.67
April			2,798	166,493	2.60	2.90
May			4,412	271,283	4.10	4.73
June			3,336	198,506	3.10	3.46
July			1,506	92,600	1.40	1.61
August			377	23,181	.35	.40
September			129	7,676	.12	.13
October			75	4,612	.07	.08
November			75	4,463	.07	.08
December			323	19,860	.30	.35
The year			1,673	1,201,489	1.55	20.96
1882.						
January			172	10,576	.16	.18
February			753	41,820	.70	.73
March			1,506	92,600	1.40	1.61
April			2,260	134,479	2.10	2.34
May			3,658	224,922	3.40	3.92
June			3,336	198,506	3.10	3.46
July			1,076	66,161	1.00	1.15
August			215	13,220	.20	.23
September			129	7,676	.12	.13
October			484	29,760	.45	.52
November			387	23,028	.36	.40
December			237	14,573	.22	.25
The year			1,184	857,319	1.10	14.96

Estimated monthly discharge of Merced River at Merced Falls, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1883.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January			344	21,152	.32	.37
February			355	19,716	.33	.34
March			915	56,261	.85	.98
April			2,260	134,479	2.10	2.34
May			5,488	337,444	5.10	5.88
June			4,412	262,532	4.10	4.57
July			1,184	72,801	1.10	1.27
August			377	23,181	.35	.40
September			237	14,102	.22	.25
October			183	11,252	.17	.20
November			161	9,580	.15	.17
December			172	10,576	.16	.18
The year			1,341	973,076	1.25	16.95
1884.						
January			237	14,573	.22	.25
February			2,712	155,996	2.52	2.72
March			3,820	234,883	3.55	4.09
April			4,896	291,332	4.55	5.07
May			5,434	334,124	5.05	5.82
June			6,510	387,372	6.05	6.75
July			4,358	267,963	4.05	4.67
August			1,130	69,481	1.05	1.21
September			237	14,102	.22	.25
October			172	10,576	.16	.18

Estimated monthly discharge of Merced River, Merced County, 1 mile above Merced Falls.[a]

[Drainage area, 1,080 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
April	5,000	1,090	2,687	133,240	1.55	1.73
May	9,450	2,700	5,419	333,201	4.97	5.73
June	8,220	3,380	5,389	320,678	4.94	5.51
July	4,560	1,090	2,096	128,878	1.92	2.21
August	2,090	220	704	43,287	.65	.75
September	250	130	183	10,889	.17	.19
October	990	150	265	16,294	.24	.28
November	730	0	399	23,742	.37	.41
December	2,090	220	577	35,478	.53	.61
1902.						
January	410	195	236	14,511	.22	.25
February	4,020	170	749	41,597	.69	.72
March	5,720	460	1,367	84,054	1.25	1.44
April	5,460	730	2,457	146,202	2.25	2.51
May	6,240	2,180	3,795	233,345	3.48	4.01
June	5,460	1,220	3,142	186,962	2.88	3.21
July	1,110	280	481	29,576	.44	.51
August	320	110	191	11,744	.18	.20
September	110	65	88	5,236	.08	.09
October	280	65	90	5,534	.08	.09
November	1,110	90	246	14,638	.23	.25
December	1,340	195	303	18,631	.28	.32
The year	6,240	65	1,095	792,030	1.01	13.6

[a] U. S. Geol. Survey.

MILL CREEK.

See King River, Mill Creek.

MILL CREEK.

This stream is one of the larger tributaries of Santa Ana River, although on account of its importance for irrigation it is generally considered as an independent stream. It rises on the western slope of the San Bernardino Mountains, draining the area immediately south of the headwaters of Santa Ana River. Mill Creek appears from its canyon about 5 miles east of Redlands. The Crafton Water

Company diverts all the water of this creek at the mouth of the canyon, particularly in the summer. The water passes over a weir, and the volume is therefore determined with considerable accuracy.

Discharge measurements of Mill Creek at headworks Crafton Canal, San Bernardino County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Nov. 9, 1898	F. H. Olmsted	15.2
Dec. 8, 1898	do	12.6
July 15, 1899	S. G. Bennett	7.4
July 23, 1898	J. B. Lippincott	11.8
Jan. 12, 1899	S. G. Bennett	10.8
Apr. 29, 1898	J. B. Lippincott	18.9
Oct. 2, 1900	W. W. Cockins, jr	[a]8.6
Apr. 12, 1898	J. B. Lippincott	15.7
June 12, 1898	do	18.1
Sept. 8, 1898	do	13.1
Oct. 18, 1898	F. H. Olmsted	15.3
Mar. 23, 1899	S. G. Bennett	15.6
May 6, 1899	do	14.6
May 31, 1899	do	11.6
June 15, 1899	do	6.8
July 27, 1899	do	4.3
Aug. 24, 1899	do	[b]5.7
Do	do	[c]1.5
Apr. 14, 1900	do	10.8
July 13, 1900	do	[b]5.4
Do	do	[c]3.4
Mar. 30, 1901	do	20.0
May 5, 1900	do	[b]39.0
Do	do	[d]8.0
July 6, 1901	do	23.3
Feb. 18, 1899	do	10.4
July 29, 1896	J. H. Quinton	14.2
Dec. 5, 1901	S. G. Bennett	14.5
Apr. 5, 1902	do	15.7
Do	do	[b]5.4
May 31, 1902	do	19.2
July 10, 1902	do	10.8
Sept. 3, 1902	W. B. Clapp	5.3
Nov. 5, 1902	S. G. Bennett	12.3

[a] Of which 1.35 is pumped. [b] In creek. [c] Pumped. [d] Canal.

Discharge measurements of Mill Creek at Mountain Home, San Bernardino County.

[Measurements made by Edison Electric Company.]

Date.	Discharge.
Sept. 15, 1898:	*Sec.-feet.*
7 a. m	11.74
7.30 a. m	11.74
8 a. m	11.58
8.30 a. m	11.74
9 a. m	11.74
9.30 a. m	11.42
10 a. m	11.26
10.30 a. m	11.26
11 a. m	11.08
11.30 a. m	10.78
12 m	10.48
12.30 p. m	10.32
1 p. m	10
1.30 p. m	9.84
2 p. m	9.54
2.30 p. m	9.40
3 p. m	9.24
3.30 p. m	9.24
4 p. m	9.24
4.30 p. m	9.24
5 p. m	9.24
5.30 p. m	9.24
6 p. m	9.54
6.30 p. m	9.54
12-hour mean	10.35
Sept. 15, 1898:	
7 p. m	9.54
7.30 p. m	9.42
8 p. m	9.84
8.30 p. m	9.84
9 p. m	10
9.30 p. m	10.16
10 p. m	10.36
10.30 p. m	10.48
11 p. m	10.48
11.30 p. m	10.78
12 midnight	10.62

Date.	Discharge.
Sept. 16, 1898:	*Sec.-feet.*
12.30 a. m	10.7[illegible]
1 a. m	11.0[illegible]
1.30 a. m	11.[illegible]
2 a. m	11.0[illegible]
2.30 a. m	11.3[illegible]
3 a. m	11.3[illegible]
3.30 a. m	11.3[illegible]
4 a. m	11.3[illegible]
4.30 a. m	11.3[illegible]
5 a. m	11.4[illegible]
5.30 a. m	11.3[illegible]
6 a. m	11.4[illegible]
6.30 a. m	11.4[illegible]
12-hour mean	10.7[illegible]
Sept. 16, 1898:	
7 a. m	11.[illegible]
7.30 a. m	11.[illegible]
8 a. m	10.[illegible]
8.30 a. m	11.[illegible]
9 a. m	11.[illegible]
9.30 a. m	10.[illegible]
10 a. m	10.[illegible]
10.30 a. m	10.[illegible]
11 a. m	10.[illegible]
11.30 a. m	10.[illegible]
12 m	10.[illegible]
12.30 p. m	9.[illegible]
1 p. m	9.[illegible]
1.30 p. m	9.[illegible]
2 p. m	9.[illegible]
2.30 p. m	9.[illegible]
3 p. m	9
3.30 p. m	9.[illegible]
4 p. m	8.[illegible]
4.30 p. m	8.[illegible]
5 p. m	8.[illegible]
5.30 p. m	8.[illegible]

Discharge measurements of Mill Creek at Mountain Home, etc.—Continued.

Date.	Discharge.	Date.	Discharge.
Sept. 16, 1898:	*Sec.-feet.*	Sept. 17, 1898:	*Sec.-feet.*
6 p. m	9.08	12.30 a. m	10.48
6.30 p. m	9.40	1 a. m	10.48
12-hour mean	9.92	1.30 a. m	10.64
		2 a. m	10.78
Sept. 16, 1898:		2.30 a. m	10.78
7 p. m	9.54	3 a. m	10.78
7.30 p. m	9.68	3.30 a. m	10.78
8 p. m	9.68	4 a. m	10.78
8.30 p. m	9.84	4.30 a. m	11.08
9 p. m	9.84	5 a. m	11.08
9.30 p. m	9.84	5.30 a. m	11.08
10 p. m	10.16	6 a. m	11.26
10.30 p. m	10.16	6.30 a. m	11.26
11 p. m	10.32	12-hour mean	10.46
11.30 p. m	10.32		
12 midnight	10.32		

Discharge measurements of Mill Creek, San Bernardino County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
July 15, 1899	S. G. Bennett	8.9	Redlands Power Co., lower intake.[a]
Oct. 2, 1900	W. W. Cockins, jr	7.3	Do.

[a] Loss from this intake to head of Crafton Canal, 1.46 second-feet.

Estimated monthly discharge of Mill Creek at Crafton Canal headworks.

[Drainage area, 47 square miles.]

Month.	Discharge.			Total discharge	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile	Depth
1895.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
August	27.6	24.0	24.5	1,505	0.52	0.6
September	26.5	19.5	22.0	1,310	.47	.5
October	24.5	17.0	19.6	1,205	.42	.4
1896.						
May	21.4	9.4	13.4	825	.28	.3
June	16.0	5.1	10.3	615	.22	.2
July	16.0	6.1	11.5	709	.24	.2
August	13.2	8.7	11.6	716	.25	.2
September	15.0	7.4	11.5	687	.24	.2
October	13.1	9.0	10.5	637	.22	.2
1899.						
February	13.0	11.0	11.6	644	.25	.2
March	16.0	10.0	12.2	750	.26	.3
April	13.0	11.0	11.8	702	.25	.2
May	12.0	10.0	11.2	689	.23	.2
June	17.0	4.0	8.7	518	.19	.2
July	7.2	4.8	5.8	357	.12	.1
August	7.2	2.9	5.8	357	.12	.1
September	5.7	2.0	4.1	244	.09	.1
October	8.5	4.3	6.5	400	.14	.1
November	11.2	6.1	8.6	512	.18	.2
December	14.6	5.3	9.5	584	.20	.2
1900.[a]						
January	10.6	9.8	10.0	615	.22	.2
February	10.6	9.8	10.0	555	.22	.2
March	13.2	9.6	10.0	615	.22	.2
April	13.3	8.9	10.0	595	.22	.2
May	17.0	8.2	12.0	738	.27	.3
June	8.2	5.3	7.0	417	.16	.1
July	6.3	3.3	5.0	307	.11	.1
August	5.7	4.3	5.0	307	.11	.1
September	5.7	4.3	5.0	298	.11	.1
October	5.8	3.8	5.0	307	.11	.1
November 1 to 17	8.5	5.1	5.0	298	.11	.1

[a] Exclusive of pumped water.

Estimated monthly discharge of Mill Creek at Crafton Canal headworks—Cont'd.

Month.	Discharge.			Total.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
une 19 to 30	20.9	19.4	20.1	478	.43	.19
uly	19.1	13.9	15.0	975	.34	.39
ugust (23 days)[a]	50.0	15.0	19.1	870	.41	.35
eptember	16.6	11.4	14.0	835	.30	.33
ctober	13.2	12.3	12.6	774	.27	.31
ovember	12.3	11.6	12.3	731	.26	.29
ecember	12.3	10.3	12.0	738	.26	.30

[a] On August 16 a cloudburst in Mill Creek Canyon and Crafton Hills filled zanje and supply anal with sand. No record from August 16 to 23, inclusive.

MILL CREEK, GREEN SPOT PIPE LINE.

See Santa Ana River, Green Spot pipe line.

MILL CREEK.

See Stanislaus River, Mill Creek.

MILL FLUME AND PUMP, RIVERSIDE WATER COMPANY.

See San Bernardino Valley.

MISSION CREEK.

Discharge measurements of Mission Creek, Santa Barbara County, 200 feet above dam.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
an. 15, 1888	A. Poett	0.93
an. 24, 1888	do	2.80
eb. 7, 1888	do	1.37
ar. 16, 1888	do	2.23
ly 26, 1888	do	.36
ly 13, 1889	do	.43
ug. —, 1889	G. F. Wright	.46
pt. 1, 1889	A. Poett	.32
ne 11, 1892	do	.36
ne 17, 1900	R. Moyer	[a].05

[a] Above diversions, but not on bed rock.

MOHAVE RIVER.

The streams forming the headwaters of this river have their source on the northern slope of the Sierra Madre and flow northerly, the river finally disappearing in the sands of the Mohave Desert. At Victorville, a station on the Atchison, Topeka and Santa Fe Railroad, the river passes through a narrow gorge, locally known as The Narrows. This place has been under investigation as a possible dam site, and soundings for the depth of bed rock were made by the United States Geological Survey during the season of 1899. The greatest depth of bed rock was found to be 54 feet. The diamond drill showed the rock to be a fine-grained granite.[a] Above The Narrows the valley broadens into a large reservoir site, and at the 145-foot flow line is said to cover 7,718 acres. In order to determine the amount of water available for storage for this reservoir, a gaging station was established February 27, 1899. The rod is a 2 by 6 inch timber, bolted to a vertical cliff on the right bank of the river, 60 feet upstream from the wagon bridge. The bench mark is top of east rail of the Santa Fe track, 75 feet south of center of wagon bridge over track. The zero mark of rod is 12.84 feet below bench mark.

Discharge measurements of Mohave River at Victorville Narrows, San Bernardino County.

Date.	Hydrographer.	Gage height.	Discharge
1899.		*Feet.*	*Sec.-ft.*
Feb. 27	B. Cole	1.0	4
May 5	S. G. Bennett	.9	3
June 13	do	.9	3
July 26	do	.85	2
Sept. 5	do	.85	2
1900.			
Apr. 13	do	.9	3
Apr. 28	P. H. Leahy	.9	3
May 11	do	.9	3
May 23	do	.9	3
May 29	do	.9	3
June 3	do	.9	3
June 20	do	.85	2
July 6	do	.85	
July 25	do	.85	2

[a] Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 4, 1901, p. 472.

Discharge measurements of Mohave River at Victorville Narrows, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Sec.-feet.*
Feb. 11	S. G. Bennett	1.4	664
Mar. 4	P. H. Leahy	1.3	512
Mar. 25	do	.9	50
Apr. 9	do	.9	39
Apr. 27	do	.9	48
May 10	do	.85	47
May 25	do	.85	51
June 10	do	.85	43
June 25	do	.9	42
July 12	do	.9	40
July 28	do	.9	42
Aug. 8	do	.9	45
Aug. 31	do	.9	55
Sept. 6	do	.9	49
Sept. 20	do	.9	61
Oct. 5	do	.9	57
Oct. 24	do	.9	82
Nov. 6	do	.9	78
Nov. 24	do	.9	76
Dec. 10	do	.9	76
Dec. 25	do	.9	69
1902.			
Jan. 4	do	.9	47
Jan. 21	do	.9	53
Feb. 1	do	.9	58
Feb. 25	do	.9	63
Mar. 5	do	.9	66
Mar. 29	do	.9	66
Apr. 5	do	.9	67
Apr. 19	do	.9	62
Apr. 26	do		47
May 10	do		37
May 25	do		49
June 8	do		53
June 27	do		47
July 5	do		38
July 26	do		41
Aug. 9	do		48
Aug. 15	do		33
Oct. 20	do		49
Oct. 30	do		45
Nov. 10	do		43
Nov. 27	do		50
Dec. 11	do		68
Dec. 19	do		69
Dec. 27	S. G. Bennett		55

Estimated monthly discharge of Mohave River at Victorville.

[Drainage area 400 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1899.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
January						
February						
March	60	28	37	2,275	0.09	
April	60	28	37	2,202	.09	
May	44	28	33	2,029	.08	
June	44	28	29	1,726	.07	
July	28	22	27	1,660	.07	
August	28	17	24	1,476	.06	
September	22	22	22	1,309	.05	
October	28	17	23	1,414	.06	
November	44	22	27	1,607	.07	
December 1 to 13	28	28	28	1,722	.07	
1900.						
January	44	44	44	2,705	.11	
February	60	44	49	2,721	.12	
March	80	44	57	3,505	.14	
April	44	33	35	2,083	.09	
May	33	33	33	2,029	.08	
June	33	25	30	1,785	.08	
July	29	25	26	1,599	.06	
August	29	29	29	1,783	.07	
September	29	29	29	1,726	.07	
October	33	29	32	1,968	.08	
November	3,200	33	139	8,271	.35	
December	33	33	33	2,029	.08	
The year	3,200	25	45	32,204	.11	

Estimated monthly discharge of Mohave River at Victorville—Continued.

Month.	Discharge.			Run-off.		
	Maximum.	Minimum.	Mean.	Total discharge.	Per square mile.	Depth.
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	4,180	50	183	11,252	0.46	0.53
February	4,820	50	925	51,372	2.31	2.41
March	660	50	178	10,945	.45	.52
April	44	44	44	2,618	.11	.12
May	49	49	49	3,013	.12	.14
June	42	42	42	2,499	.11	.12
July	40	40	40	2,460	.10	.12
August	50	50	50	3,074	.13	.15
September	55	55	55	3,273	.14	.16
October	69	69	69	4,243	.17	.20
November	77	77	77	4,582	.19	.21
December	73	73	73	4,489	.18	.21
The year	4,820	40	149	103,820	.37	4.89
1902.						
January	53	47	50	3,074	.13	.15
February	63	58	60	3,332	.15	.16
March	66	66	66	4,058	.17	.20
April	67	47	59	3,511	.15	.17
May	49	37	43	2,644	.11	.13
June	53	47	50	2,975	.13	.14
July	41	38	40	2,460	.10	.12
August	48	33	40	2,460	.10	.12
September	(a)	(a)	(a)	2,618	.11	.12
October	49	45	47	2,890	.12	.14
November	50	43	46	2,737	.12	.13
December	69	55	65	3,997	.16	.18
The year	69	33	51	36,756	.13	1.76

a Estimated.

MOKELUMNE RIVER.

The Mokelumne River drains 537 square miles of the western slope of the Sierra Nevada above Electra, Cal. A gaging station was established at this point by Burr Bassell, C. E., while employed by the Standard Electric Company. Daily gage readings were taken from January 1 to June 30, 1901, and numerous meter measurements were made.

Discharge measurements of Mokelumne River, Amador County.

Date.	Hydrographer.	Gage height.	Discharge.	Locality
1900.		*Feet.*	*Second-feet.*	
Sept. 12	S. G. Bennett		37	Amador ditch at Camp Tabeaud.[a]
Sept. 12	do		4.8	Butte ditch above Electra.
1901.				
Jan. 8	B. Bassell	5.9	1,717	Electra.
Feb. 4	do	4.2	608	Do.
Feb. 15	do	4.8	966	Do.
Feb. 19	do	11.0	13,213	Do.
Feb. 22	do	8.6	6,330	Do.
Feb. 26	do	7.4	3,846	Do.
Mar. 4	do	6.6	2,723	Do.
May 3	do	6.2	2,232	Do.
May 21	do	6.7	3,016	Do.
1902.				
Aug. 14	E. T. Perkins		51	Do.
Aug. 14	do		30	Electra power plant discharge.
	Total		81	
1895.				
Jan. 6	J. B. Lippincott	12.25	1,063	Lodi.[b]
Mar. 20	do	8.0	1,068	Do.
Aug. 27	do	1.3	91	Do.
1899.				
Aug. 20	do		56	Do.
Sept. 14	S. G. Bennett		33	Mokelumne Hill.

[a] Capacity of ditch, 64 second-feet; 25 second-feet carried out of basin to Jackson and Sutter Authority, Burr Bassell.

[b] The Woodbridge diversion dam, 2 miles below Lodi, affects gage heights.

Discharge measurements of Mokelumne River, Amador County—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
1900.		*Feet.*	*Sec.-feet.*	
Sept. 12	S. G. Bennett		15	Mokelumne Hill.
1902.				
Aug. 12	do	2.8	40	Woodbridge Canal at head.
Aug. 16	L. Lawson	3.0	29	Do.
Aug. 12	S. G. Bennett		33	At Woodbridge.
Aug. 13	do	1.0	67	¼ mile below Lancha Plana dam.
Aug. 14	E. T. Perkins		51	Amador ditch, ¼ mile above tunnel.
Aug. 14	do		53	Standard Power Canal at flume No. 59, near Electra.
Aug. 15	do		21	Mokelumne ditch in flume, South Fork Mokelumne River.
Aug. 15	do		1.7	Middle Fork, 150 feet below bridge near West Point.
Aug. 15	do		61	North Fork, ¼ mile above bridge near West Point.
Aug. 16	do		4.8	Mokelumne ditch, 2 miles southeast Fort Mountain, South Fork.
Aug. 14	L. Lawson		65	Clements.
Aug. 15	do		126	¼ mile below Lancha Plana dam.

Estimated monthly discharge of Mokelumne River at Lone Star Mills.[a]

[Drainage area 657 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1878.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
November[b]			33	1,964	0.05	0.06
December[b]			33	2,029	.05	.06
1879.						
January[b]	2,107		328	20,168	.50	.58
February	7,575	134	1,198	66,534	1.82	1.99
March	3,420	676	1,369	84,177	2.08	2.40
April	5,072	1,579	3,065	182,380	4.67	5.21
May	6,170	1,348	3,247	199,650	4.94	5.69
June	5,610	1,579	3,629	215,941	5.52	6.16
July	1,117	288	538	33,080	.82	.95
August[b]			164	10,084	.25	.29
September[b]			26	1,547	.04	.04
October[b]			19	1,168	.03	.03
November[b]			59	3,511	.09	.10
December	624	224	465	28,592	.71	.82
The year			1,175	846,832	1.79	24.16
1880.						
January	288	256	279	17,155	.42	.48
February	520	288	396	22,778	.60	.65
March	728	520	644	39,598	.98	1.1
April	9,642	728	4,553	270,922	6.93	7.73
May	8,071	3,048	5,031	309,344	7.66	8.83
June	7,326	4,685	6,054	360,238	9.21	10.27
July	5,201	572	2,745	168,783	4.18	4.82
August	480	134	365	22,443	.55	.63
September	134		29	1,726	.04	.05
October[b]			164	10,084	.25	.29
November[b]			98	5,831	.15	.17
December	998		291	17,893	.44	.51
The year			1,721	1,246,795	2.61	35.77

[a] Authority, California State engineering department.

[b] Estimated from run-off of neighboring streams and from previous measurements.

Estimated monthly discharge of Mokelumne River at Lone Star Mills—Cont'd.

Month.	Discharge.			Run-off.		
	Maximum.	Minimum.	Mean.	Total discharge.	Per square mile.	Depth.
1881.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	8,536	192	1,037	63,763	1.58	1.82
February	8,852	624	3,049	169,333	4.64	4.83
March	2,701	728	1,126	69,235	1.71	1.97
April	4,556	1,810	3,195	190,116	4.86	5.42
May	4,298	1,579	3,034	186,553	4.62	5.32
June	2,701	572	1,237	73,607	1.88	2.10
July	520		159	9,777	.24	.28
August[a]			98	6,026	.15	.17
September[a]			98	5,831	.15	.17
October[a]			66	4,058	.10	.12
November[a]			207	12,317	.32	.36
December[a]			624	38,368	.95	1.10
The year			1,160	828,984	1.77	23.66
1882.[a]						
January			591	36,339	.90	1.04
February			624	34,655	.95	.99
March			1,971	121,192	3.00	3.46
April			2,628	156,377	4.00	4.46
May			4,927	302,949	7.50	8.65
June			3,285	195,471	5.00	5.58
July			788	48,452	1.20	1.38
August			66	4,058	.10	.12
September			59	3,511	.09	.10
October			230	14,142	.35	.40
November			207	12,317	.31	.35
December			207	12,728	.31	.36
The year			1,298	942,191	1.98	26.89

[a] Estimated from run-off of neighboring streams and from previous measurements.

Estimated monthly discharge of Mokelumne River at Lone Star Mills—Cont'd.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1883.[a]	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January			414	25,456	0.63	0.73
February			328	18,216	.50	.52
March			591	36,339	.90	1.04
April			1,971	117,283	3.00	3.35
May			3,942	242,384	6.00	6.92
June			2,628	156,377	4.00	4.46
July			657	40,397	1.00	1.15
August			263	16,171	.40	.46
September			98	5,831	.15	.17
October			98	6,026	.15	.17
November			132	7,855	.20	.22
December			132	8,116	.20	.23
The year			938	680,451	1.43	19.43
1884.[a]						
January			164	10,084	.25	.29
February			1,971	113,373	3.00	3.24
March			3,942	242,384	6.00	6.92
April			3,942	234,565	6.00	6.69
May			3,285	201,987	5.00	5.76
June			2,957	175,954	4.50	5.03
July			2,628	161,589	4.00	4.61
August			657	40,397	1.00	1.15
September			131	7,795	.20	.22
October			98	6,026	.15	.17

[a] Estimated from run-off of neighboring streams and from previous measurements.

Estimated monthly discharge of Mokelumne River at Electra.[a]

[Drainage area, 537 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	4,600	330	1,000	61,488	1.86	2.14
February	13,210	610	3,302	183,384	6.15	6.40
March	4,020	1,130	2,004	123,221	3.73	4.30
April	3,160	950	2,040	121,388	3.80	4.24
May	9,980	1,960	4,627	284,503	8.62	9.93
June	6,790	1,350	3,833	228,145	7.14	7.97
July	.....	.....	260	15,987	.48	.55
August	.....	.....	190	11,683	.35	.40
September	.....	.....	60	3,570	.11	.12
October	.....	.....	76	4,673	.14	.16
November	.....	.....	210	12,496	.39	.44

[a] Authority, United States Geological Survey.

MONO LAKE DRAINAGE.

Discharge measurements in Mono Lake drainage basin, Mono County, Cal.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
July 29, 1902	F. H. Olmsted	46.72	Mill Creek, just below Lundy Lake and above all diversions.
July 30, 1902	do	89.00	Leevining, just above Rhinedollar Lake.
Aug. 1, 1902	do	26.36	Walker Creek, easterly from Bloody Canyon.
Do	do	21.65	Parker Creek.
Do	do	62.40	Rush Creek, above Silver Lake.

NIAGARA CREEK.

See Stanislaus River, Niagara Creek.

OWENS RIVER.

Discharge measurements of Owens River, Inyo County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. 4, 1902	F. H. Olmsted	26.87	Mammoth Creek at sawmill.
Do	do	37.14	Convict Creek near crossing of Bishop road.

PACOIMA CANYON.

See Los Angeles River, Pacoima.

PADARO CREEK.

Discharge measurement of Padaro Creek, Santa Barbara County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Aug. —, 1899	G. F. Wright	0.3

PALLETT CREEK.

See Big Rock Creek, Pallett Creek.

PASADENA MESA.

UNDERGROUND WATER OBTAINED FROM THE BED OF ARROYO SECO AND PASADENA MESA.

An examination of the underground water supply in the vicinity of Pasadena was made by Mr. J. B. Lippincott in October, 1898, the results of which are given in the following paragraphs:

Pasadena Mesa, lying south of the Sierra Madre, is bounded on the west, along the eastern bank of Arroyo Seco, by a low range of granite and clay hills; on the south by Raymond Hill, which is of sandstone, and by a dike, the capping of which apparently consists of adobe or clay. This dike extends from Raymond Hill, on the south side of the city of Pasadena, in a direction a little north of east, through Sunny Slope and Baldwin ranches to the base of the Sierra Madre near the mouth of Santa Anita Canyon. The mesa proper consists of deposits of sand, gravel, and bowlders, the larger bowlders lying near the mountains and the finer material near the southern slope. The voids in this absorbent material act as a storage reservoir, being filled by the flood waters issuing from the steep slopes on the southern face of the Sierra Madre. The underground waters are reenforced by the return water from irrigation on the mesa. From 1893 to 1902, inclusive, was a period of unusual drought, but most of the developments were new in 1898.

Arroyo Seco, draining 21 square miles of the Sierra Madre, issues from these mountains on the north side of Pasadena Mesa, passes through an opening in a granite spur known as Devils Gate, and joins Los Angeles River at Los Angeles. Between the point where the water from this basin issues from the mountains and Devils Gate lies a broad river bottom 2 miles in length, composed of coarse material. In passing over this the water sinks rapidly, diminishing in volume from the mouth of the canyon to Devils Gate.

Pasadena water companies have built extensive development tunels above Devils Gate, cross cutting beneath the eastern bank and nder the mesa land. A submerged dam at Devils Gate assists the nnel developments by intercepting the underflow. An examination these tunnels shows that no impervious stratum is encountered ter the granite ledge at Devils Gate is passed. Of the water btained from these development works, 69 per cent is gained from ie portion of the tunnel which is beneath the mesa. A well about

FIG. 8.—Map showing location of wells near Pasadena.

4,000 feet upstream from the tunnel and 200 feet deep, in the bed of he wash near the mouth of the mountain canyon of the Arroyo Seco, was drained by the extension of this line of tunnels under Pasadena Mesa.

From the investigations the conclusion is reached that the water from Arroyo Seco which sinks between the mouth of the canyon proper and Devils Gate passes under the eastern bank of Arroyo Seco between these points and augments the underground water of

Pasadena Mesa. Otherwise it would be difficult to account for the large amount of water which is obtained from the lower development works at the southern dike of Pasadena Mesa. This mesa is underlain throughout with a sheet of water extending from the foot of the mountains, where its depth below the surface is from 150 to 200 feet, to the dike at its southern exposure, where the water is practically at the surface, making itself manifest in numerous small springs which rise in drainage lines on the southern face of the dike. With the exception of the Arroyo Seco developments, which in the tabulations are classified by themselves, the principal water product of this mesa is obtained along these drainage lines from the springs. Numerous wells from which water is pumped have been sunk and tunnels have been run through the dike into the water-bearing gravel.

An interesting feature of these development works is the constant strife existing between the various tunnel and well owners along the dike. For instance, the owner of a certain piece of property discovered by a tunnel the presence of a considerable body of water on his land; his neighbor to the south, whose land is at a lower elevation, drained the first tunnel by digging another on a lower grade and extending it to his northern property line. This has been done repeatedly, in some cases the water having been so diverted by two or three owners in succession.

The wells are usually bored and are lined with 7-inch casing. South of the Santa Fe Railroad a charge of 50 cents a foot is made for completing the first 50 feet in depth of the well, with an increase of 50 cents per foot for each additional 50 feet in depth. North of the railroad, where the bowlders are larger, a charge of from 10 to 20 per cent more is made for boring. These prices do not include the cost of casing. The data given below concerning depth of wells and depth of water were in nearly all cases obtained from statements made by the owners.

On the following pages is given a compilation of facts with reference to the depth of water in wells through the district and a summary of the water crop from the principal development works. It has been impossible to form an exact estimate of the amount of water taken for domestic use and for minor irrigation purposes from the large number of small wells on the mesa, but the water from the larger developments has been accurately measured and included in this summary.

DESCRIPTION OF WELLS IN PASADENA MESA.[a]

1. Gidding; on Colorado street between Hollister and Chester streets; elevation, 815 feet; depth to water, 103 feet; dug mostly through gravel with no hard pan; digging cost $1 per foot and 25 cents extra for every 25 feet additional; 118 feet deep, with 6 feet of water; elevation of water, 712 feet.

[a] The unit of measurement is the California miner's inch, which is 0.02 of 1 cubic foot per second.

. McCallum; Colorado street, in McCallum wash; elevation, 785 feet; 151 feet p; was dug originally 83 feet; at 90 feet sandstone for 10 feet; 101 feet from face to water; 50 feet of water; elevation of water, 684 feet; water raised by ıdmill.

. Hoover; a bored well with windmill; 115 feet deep, with 17 feet of water; ʌation, 775 feet; water elevation, 677 feet.

. Moses; bored well; 200 feet deep; elevation 790 feet; water elevation, 684 feet; gi:ally 100 feet of water, now 94 feet, commencing 106 feet from the surface; horsepower gasoline engine with 8-inch stroke, 3-inch cylinder, pumping 1,000 lons an hour.

. King; 227 feet deep; elevation, 800 feet; water elevation, 678 feet; originally feet of water, now about 105 feet; water raised by an engine with 12-inch ɔke and 4-inch cylinder, pumping 2,500 gallons per hour.

. Stevens; 121 feet deep; 31 feet of water; 90 feet to water surface; elevation, feet; water elevation, 691 feet; was dug thirteen years ago.

. McAdam; 150 feet deep; 57 feet from surface to water; elevation, 740 feet; ter elevation, 683 feet.

. Merwin; 95 feet deep; 55 feet to water; elevation, 735 feet; water elevation, feet; pump capacity, 20 gallons per minute; costs 3¼ to 4 cents an hour to run ;ine with gasoline.

. Butler; bored well; 93 feet deep; 48 feet from surface to water, originally 40 t; elevation, 718 feet; water elevation, 670 feet.

0. Hutchinson; bored well; 230 feet deep; 36 feet from surface to water; ele- ion, 713 feet; water elevation, 677 feet; well bored through clay; pressure nes from below.

1. Daniels; 107 feet deep; 40 feet from surface to water; water 67 feet deep; ʌation, 715 feet; water elevation, 675 feet; strata of clay and bowlders with ırse gravel at bottom were encountered.

2. Hodge; 169 feet deep; 33 feet to water; elevation, 725 feet; water elevation, feet.

3. Miles; bored well; 225 feet deep; 143 feet to water; elevation, 817 feet; water ʌation, 674 feet.

4. Wilkeson; 177 feet deep; 30 feet from surface to water; elevation, 720 feet; ter elevation, 690 feet; Jack Butler, well borer, says that wells during 1898 re 15 feet lower than in previous years.

5. Ackerman; bored well; 149 feet deep; 75 feet from surface to water; eleva- ı, 710 feet; water elevation, 635 feet.

6. Thorndyke; 275 feet deep; 30 feet from surface to water; elevation, 705 feet; ter elevation, 675 feet; fine clay encountered at 69 feet and 73 feet from sur- e, the remainder being gravel strata.

7. Lamanda Park; 180 feet deep; originally 80 feet from surface to water; ele- ion, 740 feet; present water elevation, 680 feet.

8. Titus; 558 feet deep; from surface to water, 12 feet, originally 4 feet; eleva- ı, 690 feet; water elevation, 678; several strata of cement 1 inch thick were ountered.

9. Butler; 175 feet deep; 75 feet from surface to water; elevation, 720 feet; ter elevation, 645 feet.

0. Graves; 88 feet deep; 40 feet from surface to water; elevation, 720 feet; ter elevation, 680 feet.

1. Krouser; 113 feet deep; 15 feet from surface to water; elevation, 700 feet; ter elevation, 685 feet.

2. Wakefield; 60 feet deep; originally 20 feet to water, now 30 feet; elevation, feet; water elevation, 673 feet.

23. Pavey; 360 feet deep; water elevation, 670 feet; originally flowed 16 miner's inches of water; still flowing, but in less volume.

24. Chapman; flowing well; 175 feet deep. There are about 12 wells flowing on this ranch.

25. Hassleys; 500 feet deep; elevation, 600 feet; originally artesian, but now cut by a tunnel at a lower elevation.

26. Raymond; 40 feet to water, which is 4 feet deep; water fell 2 feet during season of 1898; 91 miner's inches of water were pumped from this well during October, 1898; well is brick lined and 12 feet in diameter.

27. Marengo tunnel; run into Raymond's hill at Terminal Railway, Fair Oaks station; it is discharging 18 miner's inches. This tunnel drained a small run on the west side of Fair Oaks avenue.

28. Fluer; dug well, Ipswich street; depth, 48 feet; water, 12 feet; dug in October, 1897; at first there was a supply of 50 miner's inches, but the supply has diminished to 30 miner's inches; a 6-inch centrifugal pump, with 20-horsepower engine, pumps out the well in 1.5 hours.

29. Stoneman tunnel; was first run in 1892, 178 feet, and in summer of 1898 was extended 164 feet; flows 14.4 miner's inches.

30. Graves tunnel; 530 feet of tunnel and about 100 feet of ditch; water 36 feet below the surface of the ground at the upper end; 20 miner's inches of water obtained.

31. Oak Knoll; about the same class as Rhodes well and discharging the same amount of water, 4 miner's inches.

32. Brickyard well; near Lake avenue, northeast from Oak Knoll; 40 feet; well are through clay, 7 feet through sand and gravel; 7 miner's inches of water is obtained; this is a brick-lined dug well.

33. Rhodes well; near corner of Lake avenue and Hawkeye street; 49 feet deep and water approximately 8 feet in depth; steam plant, 15-horsepower boiler, with Smith valve pump; a continuous flow of 4 miner's inches is obtained.

34. Alhambra water, in Mayberry Canyon; 64 miner's inches is obtained, which is not the full capacity of the plant. There are six wells, from 350 to feet deep, of which five are being pumped and one flows.

35. Patton tunnel, near Kewen Lake; produces 7 miner's inches.

36. Surface water; Patton water in West Canyon, 2 miner's inches.

37. Patton water, East Canyon; 24 miner's inches. (San Gabriel water included in this.)

38. San Gabriel Mission; 24.9 miner's inches; comes from the same canyon as Patton water in East Canyon; it is surface water and has been reduced by development works.

39. Shorb water; from tunnel under orange grove on Shorb place; approximately 2 miner's inches is obtained. In small canyon northwest of house there is a stream, approximately 5 miner's inches; there are three artesian wells (No. 42) southeast of the ranch house, from which 17 miner's inches is obtained.

60. Lower Painter well; dug in 1894; 96 feet deep; water, 79 feet from surface; elevation, 1,040 feet; water elevation, 961 feet; this is a 4-foot by 7-foot dug well; the material passed through being large bowlders.

61. Upper Painter well; dug well much resembling No. 60; 162 feet deep; 43 feet to water; elevation, 1,129 feet; water elevation, 997 feet.

62. Becker; 200 feet deep; depth to water, as measured in May, 1898, 175 feet; a 6-horsepower gasoline engine is used which has pumped 5 miner's inches; a bored well; cost $250, including casing ($1 per foot plus 25 cents additional each 50 feet additional depth); elevation, 825 feet; water elevation, 652 feet.

63. Stafford; bored well; 241 feet deep; depth to water, 173 feet; elevation, feet; water elevation, 652 feet.

64. **Krank**; 300 feet deep; 290 feet to water; elevation, 1,070 feet; water elevation. 780 feet.

65. **Meers**; on E street; 300 feet deep; 75 feet of water in August, 1897; elevation, 1,060 feet; water elevation, 835 feet.

66. **Stone**; 100 feet deep; 85 feet to water; elevation, 1,040 feet; water elevation, 955 feet; approximately 15 miner's inches is obtained when pump is run. This is a dug and timbered well and cost for excavation $1.75 per vertical foot until water was struck; passed through, say, 65 feet of gravel, 15 feet of sand, and 2 feet of clay.

67. **Called Painter well**; 170 feet to water; 14 feet lower ground than No. 41; water elevation, 830 feet.

50. **Hurlbut**; bored well, about 1,300 feet deep; 95 feet through clay; but little water; elevation, 816 feet; water elevation, 745 feet.

26. **Olmsted**; 39 feet deep; elevation, 750 feet; water elevation, 740 feet; the usual depth of water from the surface is 8 feet, but in October, 1898, was 10.5 feet.

51. **Pasadena and Pacific power-house well**; elevation, 750 feet; water stands 11 feet from original surface of ground; water elevation, 739 feet.

52. **Baker**; 35 feet deep; elevation, 740 feet; water elevation, 734 feet; supply is said to come from northeast.

53. **Pasadena West Side Water Company**; about 70 feet deep and 3 feet to water; elevation, 718 feet; water elevation, 715 feet; water comes from northeast.

68. **Morehouse**; cesspool at this point of 70 feet and no water is encountered; surface elevation, 790 feet.

69. **On top** of a hill 500 feet east of No. 53; 60 feet deep and no water found; surface elevation, 825 feet.

74. **In Arroyo Seco**, at mouth of canyon; 250 feet deep and dry.

Amount of water developed in Pasadena Mesa, October, 1898.

[1 miner's inch is 0.02 of 1 cubic foot per second.]

	Miner's inches.
7. **Raymond** Improvement Company's tunnel at Fair Oaks avenue	18
3. **Marengo** well, near Atchison, Topeka and Santa Fe station, Raymond	91
3. **Surface** water in Marengo Canyon, near railroad crossing (Southern Pacific)	20
3. **Fluer** well on Ipswich street, near Santa Fe Raymond station; intermittent pumping	30
). **Las Roebles** Water Company, near new Graves tunnel	14
). **Stoneman** Canyon heads, near Fluer well	3
). **Walter Graves's** new or upper tunnel	20
. **Oak Knoll** well	4
. **Brickkiln** well	7
. **C. H. Rhodes's** well, near Lake avenue and Hawkeye street	4
. **Alhambra** water, artesian wells and air-compressing plant	64
. **Patton** tunnel, near Kewen Lake	7
. **Patton** water in west canyon	2
. **Patton** water from east canyon	24
. **San Gabriel Mission** water	25
). **Shorb** water northwest from ranch house	5
a. **Shorb** water in tunnel southwest of ranch house	2
). **Graves's** lower tunnel (dry)	0
. **Richardson's** two tunnels, near Kewin Lake	18
. **Shorb's** three artesian wells southeast of house	17
. **Pump**, 13 inches; artesian, 3 inches; tunnel, 22 inches; all belong to Shorb	38

	Miner's inches.
44. Rose well, east side Santa Anita avenue	[illegible]
45. Winston wells, Santa Anita avenue	[illegible]
46. Alexander water, east of Santa Anita avenue	[illegible]
47. Titus ranch	[illegible]
48. Sunny Slope developments	[illegible]
59. Chapman	[illegible]
Total	[illegible]

Developments near Devils Gate by the United Water Companies.

56. Pumped from well below Devils Gate, but entering tunnel above sand box	[illegible]
57. Weir at mouth of northeast tunnel	[illegible]
58. Weir at mouth of northwest tunnel	[illegible]
Total from Devils Gate	[illegible]
59. Total from North Branch	[illegible]
Total from submerged dam and from under arroyo above dam	[illegible]
Flow from the 900-foot tunnel, east bank of arroyo, or six-tenths of whole Devils Gate flow from tunnels	[illegible]
70. Richardson tunnel below Devils Gate	[illegible]
71. Wilson tunnel below Devils Gate	[illegible]
Developed at Devils Gate	[illegible]
Total upper arroyo development	[illegible]
42. Upper Painter well	[illegible]
41. Lower Painter well	[illegible]
48. Stone well	[illegible]
Pump near reservoir No. 1	[illegible]
Total	[illegible]
72. Sheep Corral Springs, in development cut	[illegible]
73. Above shaft No. 2, detail of No. 58	[illegible]

Summary of water development from Pasadena Mesa.

Devils Gate development	[illegible]
Sheep corral	[illegible]
Lower dike in 4¼ miles	[illegible]
Total	[illegible]

PASTORIA CREEK.

Discharge measurement of Pastoria Creek, Kern County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Nov. 13, 1895	J. B. Lippincott	0.04	Mouth of canyon.
Dec. 15, 1896	do	0.00	Road crossing.

PESCADERO CREEK.

Discharge measurement of Pescadero Creek, San Mateo County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Oct. 17, 1893	W. W. Brier	4.67	6 miles above Pescadero.

PILARCITOS CREEK.

Discharge measurement of Pilarcitos Creek, San Mateo County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Oct. 17, 1893	W. W. Brier	0.80	3½ miles above Half Moon Bay.

PIRU CREEK.

Discharge measurements of Piru Creek, Ventura County.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
		Feet.	*Sec.-feet.*	
Mar. 10, 1895	J. B. Lippincott	0.27	3.54	Robertson Mill.
Jan. 21, 1896	S. Stewart		18.00	Smith's.
Jan. 31, 1896	J. B. Lippincott	1.75	13.30	Do.
Aug. 11, 1898	F. H. Olmsted		0.92	French House.
Dec. 15, 1896	J. B. Lippincott		.20	Gorman Creek below Gorman Station.
Mar. 16, 1899	S. G. Bennett		[a]61.00	At Piru City, wagon road crossing.
Mar. 17, 1899	do		[a]152.00	Do.
Mar. 14, 1899	do		5.00	Narrows, near Dutton's.
Aug. 19, 1899	do		1.30	Head of Piru pipe line.
Oct. 8, 1900	W. W. Cockins, jr		2.20	Lower Piru Creek, ditches from.

[a] Ditch is carrying 10 second-feet on both dates in addition.

PIT RIVER.

Discharge measurements of Pit River, Shasta County.

Date.	Hydrographer.	Discharge.	Locality.
1901.		*Sec.-feet.*	
Sept. —	Robt. McF. Doble	2,230	Peck's Bridge.
Sept. 9	S. G. Bennett	2,682	Silverthorn Ferry.
Sept. —	Robt. McF. Doble	177	Burney Creek, tributary of Pit River.
Sept. —	do	1,447	Fall River, near mouth.
Sept. —	do	627	Hat Creek, Carbon bridge.
Sept. 9	S. G. Bennett	23	Squaw Creek, near Copper City bridge.
1902.			
Sept. 17	do	208	Pit River above mouth of Fall River, at Fall River Mills.
Sept. 16	do	1,543	Fall River, at bridge.
Do	do	583	Hat Creek, at Carbon bridge.
Sept. 15	do	2,350	Peck's bridge.
Do	do	209	Burney Creek, ½ mile below Burney Falls.
Sept. 27	Chas. A. Miller	2,508	Silverthorn Ferry.
Do	do	37	Squaw Creek, near Copper City bridge.

PLUNGE CREEK.

Discharge measurements of Plunge Creek, at headworks in canyon, San Bernardino County.

Date.	Hydrographer.	Discharge.
		Sec.-ft.
June 12, 1898	J. B. Lippincott	2.3
Sept. 9, 1898	do	.5
Mar. 25, 1899	S. G. Bennett	10.4
Aug. 25, 1899	do	.5
July 12, 1900	do	.4
Apr. 7, 1902	do	12.6
Sept. 4, 1902	W. B. Clapp	.5

POMPONIO CREEK.

Discharge measurement of Pomponio Creek, San Mateo County.

Date.	Hydrographer.	Discharge.	Locality
1893.		*Sec.-feet.*	
Oct. 17	W. W. Brier	0.27	2 miles above mouth.

POSO CREEK.

Estimated monthly discharge of Poso Creek at base of foothills.[a]

[Drainage area, 289 square miles.]

Month	Mean discharge.	Total discharge.	Run off.	
			Per square mile.	Depth.
1878.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
November	0	0	0	0
December	0	0	0	0
1879.				
January	23	1,414	0.08	0.09
February	40	2,221	.14	.15
March	20	1,230	.07	.08
April	72	4,284	.25	.28
May	52	3,197	.18	.21
June	17	1,012	.06	.07
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	75	4,463	.26	.29
December	145	8,916	.50	.58
The year	37	26,737	13	1.75
1880.				
January	347	21,336	1.20	1.38
February	665	38,251	2.30	2.48
March	751	46,177	2.60	3.00
April	838	49,864	2.90	3.24
May	578	35,540	2.00	2.31
June	145	8,628	.50	.56
July	14	861	.05	.06
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	58	3,451	.20	.22
December	145	8,916	.50	.58
The year	294	213,024	1.02	13.83

[a] Authority, State engineer. Estimated from run-off of neighboring streams.

Estimated monthly discharge of Poso Creek at base of foothills—Continued

Month.	Mean discharge.	Total discharge.	Run-off	
			Per square mile	Depth
1881.[a]	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	145	8,916	0.50	0.5
February	289	16,050	1.00	1.1
March	289	17,770	1.00	1.1
April	289	17,197	1.00	1.1
May	289	17,770	1.00	1.1
June	145	8,628	.50	.5
July				
August				
September				
October				
November	0	0	0	
December	35	2,152	.12	.1
The year	123	88,483	.42	5.7
1882.[a]				
January	35	2,152	.12	.1
February	43	2,388	.15	.1
March	145	8,916	.50	.5
April	145	8,628	.50	.5
May	29	1,783	.10	.1
June	0	0	0	
July	0	0	0	
August	0	0	0	
September	0	0	0	
October	0	0	0	
November	43	2,559	.15	.1
December	14	861	.05	.0
The year	38	27,287	.13	1.7

[a] Estimated from run-off of neighboring stream.

Estimated monthly discharge of Poso Creek at base of foothills—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1883.[a]	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	43	2,644	0.15	0.17
February	43	2,388	.15	.16
March	231	14,204	.80	.92
April	145	8,628	.50	.56
May	119	7,317	.41	.47
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	0	0	0	0
October	29	1,783	.10	.12
November	29	1,726	.10	.11
December	43	2,644	.15	.17
The year	57	41,334	.19	2.68
1884.[a]				
January	145	8,916	.50	.58
February	867	49,870	3.00	3.24
March	867	53,310	3.00	3.46
April	578	34,393	2.00	2.23
May	119	7,317	.41	.47
June	145	8,628	.50	.56
July	0		0	0
August	0		0	0
September	0		0	0
October	0		0	0

[a] Estimated from run-off of neighboring stream.

PURISSIMA CREEK.

Discharge measurement of Purissima Creek, San Mateo County.

Date.	Hydrographer.	Discharge.	Locality.
1893.		*Sec.-feet.*	
Oct. 17	W. W. Brier	2.03	1¼ miles above Purissima.

PUTAH CREEK.

Discharge measurement of Putah Creek, Napa County.

Date.	Hydrographer.	Discharge.	Remarks.
1900.		*Sec.-feet.*	
Sept. 23	S. G. Bennett	4.4	6 miles above Winters, at Devils Gate.

RABEL DAM DITCH, SAN BERNARDINO COUNTY.

See San Bernardino Valley, Rabel dam ditch.

RANCHERO DITCH, SAN BERNARDINO COUNTY.

See San Bernardino Valley, Ranchero ditch.

RED HILLS DEVELOPMENTS.

See Cucamonga Creek, Red Hills.

REDLANDS CANAL.

See Santa Ana River, Redlands canal.

RINCON CREEK.

Discharge measurements of Rincon Creek, Santa Barbara County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Aug. —, 1889	G. F. Wright	0.1
June 16, 1900	R. Moyer	.05

RUBICON RIVER.

See Middle Fork American River.

RIVERSIDE WATER COMPANY, UPPER CANAL.

See San Bernardino Valley.

SACRAMENTO RIVER.

This river rises in the extreme northeastern corner of California and flows in a general southerly direction, draining a large area in northern California between the Coast Range on the west and the Sierra Nevada on the east. It discharges into San Francisco Bay. A num-

ber of storage reservoirs have been constructed on the various tributaries of the river, and are used for hydraulic mining purposes and to a less extent for irrigation. The gaging station of the Geological Survey, established April 30, 1895, is located 12 miles above the town of Red Bluff at the crossing of the country road at Jellys Ferry. The gage consists of a vertical rod made in three sections and nailed firmly to trees near the ferry landing. A second rod is located 1,206 feet above the gage, and a third one 350 feet below the main rod, in order to determine the slope of the water surface. The three rods are referred to the same datum. Bench mark No. 1 is on an oak tree on the left bank of the river 300 feet below the cable, and is 22.429 feet above gage datum. The ferry cable is used in the discharge measurements. The channel for 1,000 feet above and below the station is nearly straight. The right bank is high, but the left bank is liable to overflow when the water rises above the 25-foot mark. The bed of the stream consists of gravel and changes only slightly. The gaging station of the State engineering department was at the mouth of the river.

Discharge measurements of Sacramento River.

Date.	Hydrographer.	Discharge.	Locality.
1878.		*Sec.-feet.*	
Oct. —	United States Engineers.	6,425	Sacramento.
1879.			
May 12	State engineering department.	16,000	Knights Landing.
July 16	do	7,000	Sacramento Slough.
May 16	do	38,000	Gray & Shaws.
May 21	do	26,000	Above mouth of American River.
July 14	do	13,000	Do.
May 22	do	39,000	Sacramento, foot of I street.
July 14	do	15,000	Do.
Mar. 3	do	40,000	Freeport.
Mar. 20	do	56,000	Do.
Jan. 24	do	12,000	Brannan Slough.

Estimated monthly discharge of Sacramento River at Collinsville.[a]

[Drainage area, 26,187 square miles.]

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth
1878.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
November	8,000	476,033	0.31	0.4
December	9,000	553,388	.34	.3
1879.				
January	12,000	737,851	.46	.5
February	30,000	1,666,115	1.14	1.2
March	110,000	6,763,640	4.20	4.8
April	110,000	6,545,450	4.20	4.6
May	75,000	4,611,570	2.86	3.3
June	45,000	2,677,686	1.72	1.9
July	16,000	983,802	.61	.7
August	8,500	522,644	.32	.3
September	6,500	386,776	.25	.2
October	8,000	491,901	.30	.3
November	7,500	446,281	.29	.3
December	27,000	1,660,165	1.03	1.2
The year	37,958	27,493,881	1.45	19.7
1880.				
January	28,000	1,721,653	1.07	1.2
February	21,000	1,207,933	.80	.8
March	22,000	1,352,727	.84	.9
April	95,000	5,652,892	3.63	4.0
May	135,000	8,300,828	5.16	5.9
June	110,000	6,545,450	4.20	4.6
July	53,000	3,258,843	2.02	2.3
August	18,000	1,106,777	.69	.8
September	9,000	535,537	.34	.4
October	7,500	461,157	.29	.3
November	7,000	416,529	.27	.3
December	20,000	1,229,752	.76	.9
The year	43,792	31,790,078	1.67	22.7

[a] Authority, State engineer.

Estimated monthly discharge of Sacramento River at Collinsville—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1881.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	95,000	5,841,332	3.63	4.18
February	115,000	6,386,776	4.39	4.57
March	77,000	4,734,545	2.94	3.39
April	90,000	5,355,372	3.44	3.84
May	70,000	4,304,132	2.67	3.08
June	25,000	1,487,603	.95	1.06
July	14,000	860,826	.53	.61
August	8,000	491,901	.30	.35
September	6,500	386,777	.25	.28
October	7,000	430,413	.27	.31
November	8,200	487,934	.31	.35
December	16,000	983,802	.61	.70
The year	44,308	31,751,403	1.69	22.72
1882.				
January	24,000	1,475,702	.92	1.06
February	22,000	1,221,818	.84	.87
March	55,000	3,381,818	2.10	2.42
April	90,000	5,355,372	3.44	3.84
May	92,000	5,656,859	3.51	4.05
June	74,000	4,403,306	2.82	3.15
July	17,000	1,045,289	.65	.75
August	8,000	491,901	.30	.35
September	6,500	386,777	.25	.28
October	10,000	614,876	.38	.44
November	14,000	833,058	.53	.59
December	11,000	676,364	.42	.48
The year	35,292	25,543,140	1.35	18.28

Estimated monthly discharge of Sacramento River at Collinsville—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth
1883.	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	12,000	737,851	0.46	0.53
February	17,000	944,132	.65	.68
March	21,000	1,291,240	.80	.92
April	73,000	4,343,801	2.79	3.11
May	80,000	4,919,008	3.05	3.52
June	32,000	1,904,132	1.22	1.36
July	12,000	737,851	.46	.53
August	7,000	430,413	.27	.31
September	6,500	386,776	.25	.28
October	7,000	430,413	.27	.31
November	7,500	446,281	.29	.32
December	7,400	455,008	.28	.32
The year	23,533	17,026,906	.90	12.19
1884.				
January	12,000	737,851	.46	.53
February	24,000	1,380,496	.92	1.07
March	80,000	4,919,008	3.05	3.52
April	105,000	6,247,934	4.01	4.47
May	111,000	6,825,124	4.23	4.88
June	90,000	5,355,372	3.44	3.84
July	31,000	1,906,116	1.18	1.36
August	12,000	737,851	.46	.53
September	7,500	446,281	.29	.32
October	8,000	491,901	.30	.35

Discharge measurements of Sacramento River, Iron Canyon, 4 miles above Red Bluff, Tehama County, Cal.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Sec.-feet.*
Oct. 30	S. G. Bennett	1.02	5,187
Dec. 13	do	2.68	9,651
1902.			
Jan. 28	do	1.35	5,912
Feb. 12	Wm. F. Luning	20.6	[a]110,824
Mar. 3	S. G. Bennett	10.6	41,570
May 10	do	5.5	18,927
Sept. 13	Chas. A. Miller	.84	4,425
Dec. 31	S. G. Bennett	3.20	9,858

[a] Float measurement.

Discharge measurements of Sacramento River at Red Bluff, Tehama County, Cal.

Date.	Hydrographer.	Gage height.	Discharge.
1894.		*Feet.*	*Sec.-feet.*
Dec. 20	A. P. Davis and J. B. Lippincott	10.7	45,000
1895.			
Mar. 19	J. B. Lippincott	4.8	15,461
Apr. 27	do	8.4	36,181
1896.			
Jan. 21	do	20.8	109,432
Jan. 22	do	17.7	83,558

Estimated monthly discharge of Sacramento River at Red Bluff, Tehama County.[a]

[Drainage area, 9,356 square miles.][b]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1895.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	123,000	15,220	47,267	2,906,320	5.052	5.824
February	65,600	13,860	26,792	1,487,940	2.864	2.982
March	85,360	15,220	32,517	1,999,418	3.475	4.007
April	33,880	26,670	29,566	1,759,300	3.160	3.526
May	48,600	16,840	30,238	1,859,250	3.232	3.726
June	18,600	9,040	12,764	759,510	1.717	1.922
July	9,040	6,150	7,235	444,863	1.364	.892
August	6,150	5,990	6,057	372,436	.647	.746
September	10,820	5,830	6,321	376,106	.676	.754
October	6,285	5,910	5,989	368,261	.640	.738
November	6,690	5,910	6,046	359,792	.646	.711
December	36,880	6,150	10,095	620,760	1.079	1.244
Per annum	123,000	5,830	18,390	13,313,956	1.9656	26.672
1896.						
January	140,000	6,150	51,702	3,179,032	5.53	6.41
February	46,860	9,040	15,231	876,120	1.63	1.76
March	74,050	9,700	25,533	1,569,981	2.73	3.15
April	72,910	16,370	30,708	1,827,271	3.28	3.66
May	81,030	19,660	35,019	2,153,252	3.74	4.35
June	21,150	8,600	13,599	809,215	1.45	1.62
July	8,380	5,990	6,907	424,694	.74	.85
August	5,910	5,660	5,788	352,858	.61	.70
September	5,830	5,660	5,696	338,977	.61	.68
October	6,555	5,660	5,730	352,336	.61	.70
November	57,200	5,660	11,260	670,058	1.20	1.34
December	106,880	11,380	33,316	2,048,546	3.56	4.09
The year	140,000	5,660	20,037	14,602,340	2.14	29.36

[a] Authority, United States Geological Survey.

[b] Drainage areas were measured from maps of United States Geological Survey.

Discharge measurements of Sacramento River at Jellys Ferry, Tehama County.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-ft.*
Apr. 30	J. B. Lippincott	12	27,255
June 30	do	6.75	8,456
Aug. 25	A. P. Davis and J. B. Lippincott	5.55	5,452
Oct. 5	J. B. Lippincott	5.5	6,046
1896.			
Jan. 21	J. B. Lippincott	25.9	105,000
Jan. 22	do	22.7	82,000
July 7	C. C. Babb	6.6	6,924
Nov. 1	Richard Gernon	5.9	6,778
1897.			
Mar. 29	Fred Lemstrom	14.4	28,319
Mar. 13	do	10.3	18,568
Apr. 3	J. B. Lippincott	10.85	21,519
Apr. 16	Fred Lemstrom	12.2	25,806
Apr. 30	do	10.3	18,544
May 14	do	9	14,719
May 28	do	7.5	10,193
June 11	do	6.5	7,277
June 28	do	6.42	6,493
July 13	do	5.95	5,032
July 28	do	5.7	5,082
Aug. 13	do	5.6	4,285
Aug. 28	do	5.5	4,490
Sept. 13	do	5.5	4,257
Sept. 28	do	5.5	4,418
Oct. 13	do	5.6	4,591
Oct. 28	do	5.7	4,202
Nov. 13	do	5.7	4,196
Nov. 28	do	5.95	6,179
Dec. 13	do	7.4	10,151
Dec. 17	J. B. Lippincott	6.85	8,802
Dec. 28	Fred Lemstrom	5.95	6,105

Discharge measurements of Sacramento River at Jellys Ferry, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge
1898.		*Feet.*	*Sec.-ft.*
Jan. 28	Fred Lemstrom	5.7	5,[illegible]
Feb. 21	do	8.3	13,11[illegible]
Feb. 28	do	15.32	42,02[illegible]
Mar. 13	do	6.95	9,49[illegible]
Mar. 28	do	6.1	7,15[illegible]
Apr. 13	do	6.1	7,21[illegible]
Apr. 27	do	6.2	7,6[illegible]
May 13	do	5.5	5,47
May 28	do	7.92	12,47[illegible]
June 3	J. B. Lippincott	7.1	9,04[illegible]
June 13	Fred Lemstrom	5.9	6,[illegible]
June 28	do	5.45	5,[illegible]
July 13	do	5.2	4,6[illegible]
July 28	do	5.1	4,[illegible]
Aug. 13	do	5	4,[illegible]
Aug. 27	do	5	4,[illegible]
Sept. 13	do	5	4,[illegible]
Sept. 28	do	5.1	4,[illegible]
Oct. 12	do	5.15	4,[illegible]
Oct. 28	do	5.15	4,[illegible]
Nov. 28	do	5.2	4,[illegible]
Dec. 13	do	5.2	4,[illegible]
Dec. 28	do	5.3	4,[illegible]
1899.			
Jan. 14	Fred Lemstrom	11.4	21,[illegible]
Jan. 28	do	7.5	10,[illegible]
Feb. 13	do	5.9	5,[illegible]
Feb. 28	do	6.1	6,[illegible]
Mar. 13	do	6.15	6,[illegible]
Mar. 29	do	11.5	21,[illegible]
Apr. 13	do	7.8	10,[illegible]
Apr. 28	do	7.3	7,[illegible]
May 13	do	6.65	7,[illegible]
June 3	do	6.9	8,[illegible]
June 13	do	5.9	6,[illegible]
June 28	do	5.5	4,[illegible]
July 13	do	5.25	4,[illegible]
July 28	do	5.05	4,[illegible]
Aug. 13	do	5.0	3,[illegible]
Aug. 28	do	5.0	3,[illegible]
Sept. 13	do	5.0	4,[illegible]
Sept. 28	do	5.0	4,[illegible]

Discharge measurements of Sacramento River at Jellys Ferry, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Sec.-ft.*
Feb. 17	Richard Gernon	6.8	8,374
Apr. 29	do	7.1	9,586
May 28	do	6.4	7,173
Sept. 20	S. G. Bennett	5.0	4,105
Dec. 18	do	10.0	18,361
1901.			
Jan. 27	S. G. Bennett	9.46	15,908
Apr. 9	do	7.8	11,112
Sept. 2	do	4.9	4,390

Estimated monthly discharge of Sacramento River at Jellys Ferry, Tehama County.

[Drainage area, 9,184 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1896.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	130,050	6,360	46,152	2,837,813	5.05	5.86
February	34,460	10,070	15,468	889,764	1.69	1.82
March	62,870	11,310	24,099	1,481,801	2.64	3.05
April	59,500	16,920	25,793	1,534,819	2.82	3.14
May	75,120	19,300	30,941	1,902,543	3.39	3.91
June	20,515	9,200	14,217	846,018	1.56	1.74
July	8,960	6,720	7,591	466,789	.83	.95
August	6,720	6,180	6,394	393,201	.70	.81
September	6,360	6,000	6,204	369,163	.68	.75
October	8,000	6,000	6,163	378,960	.67	.77
November	43,000	6,360	11,965	712,014	1.31	1.46
December	93,000	8,480	22,318	1,372,304	2.44	2.82
The year	130,050	6,000	18,109	13,185,189	1.98	27.08

Estimated monthly discharge of Sacramento River at Jellys Ferry, etc.—Cont'd.

Month.	Discharge.			Total discharge.	Run off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1897.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	49,765	8,320	14,280	878,050	1.56	1.8
February	89,100	17,420	36,108	2,005,335	3.95	4.1
March	44,340	13,100	21,790	1,339,825	2.39	2.7
April	28,710	18,830	22,807	1,357,108	2.50	2.7
May	18,520	9,200	13,737	844,660	1.50	1.7
June	9,200	6,680	7,620	453,420	.83	.9
July	6,550	5,120	5,699	350,420	.62	.7
August	5,120	4,600	4,776	293,667	.52	.6
September	4,600	4,600	4,600	273,718	.50	.5
October	6,680	4,600	4,955	304,673	.54	.6
November	8,600	5,120	5,590	332,627	.61	.6
December	16,940	5,380	7,792	479,114	.85	.9
The year	89,100	4,600	12,480	8,912,617	1.36	18.3
1898.						
January	6,525	5,835	6,120	376,307	.67	.7
February	33,600	5,835	12,479	693,049	1.37	1.4
March	22,500	6,525	9,745	599,201	1.07	1.2
April	7,260	6,525	6,872	408,911	.75	.8
May	10,800	5,375	6,632	407,789	.73	.8
June	10,500	5,150	6,674	397,130	.73	.8
July	5,150	4,475	4,700	288,994	.52	.6
August	4,475	4,250	4,276	262,923	.47	.5
September	4,475	4,250	4,280	254,677	.47	.5
October	4,925	4,475	4,631	284,751	.51	.6
November	6,892	4,475	4,785	284,727	.52	.6
December	5,950	4,700	4,991	306,887	.55	.6
The year	33,600	4,250	6,349	4,565,346	.70	9.5

Estimated monthly discharge of Sacramento River at Jellys Ferry, etc.—Cont'd.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1899.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	42,600	5,065	13,498	829,965	1.48	1.71
February	8,644	5,810	6,646	369,100	.73	.76
March	83,400	6,750	20,915	1,286,022	2.29	2.64
April	16,100	7,800	10,837	344,845	1.19	1.33
May	7,530	6,030	6,908	424,759	.76	.87
June	15,200	4,965	6,199	368,865	.68	.75
July	4,760	4,170	4,531	278,592	.50	.58
August	4,170	3,980	3,986	245,061	.44	.51
September	3,980	3,980	3,980	236,826	.44	.49
October	10,550	3,980	5,063	311,314	.55	.63
November	53,480	4,760	14,532	864,712	1.59	1.77
December	45,600	8,915	14,519	892,744	1.59	1.83
The year	83,400	3,980	9,301	6,752,805	1.02	13.87
1900.						
January	119,700	10,400	30,661	1,885,271	3.36	3.88
February	24,800	7,800	11,687	649,063	1.28	1.33
March	123,000	10,700	23,288	1,431,923	2.55	2.94
April	16,700	8,630	12,082	718,929	1.32	1.47
May	19,780	6,265	9,572	588,559	1.05	1.21
June	6,265	4,760	5,477	325,904	.60	.67
July	4,760	3,805	4,212	258,986	.46	.53
August	3,805	3,805	3,805	233,960	.42	.48
September	5,170	3,630	3,981	236,886	.44	.49
October	21,520	3,805	6,381	392,352	.70	.81
November	28,800	4,560	8,205	488,231	.90	1.00
December	80,100	6,030	15,553	956,317	1.70	1.96
The year	123,000	3,630	11,242	8,166,381	1.23	16.77

Estimated monthly discharge of Sacramento River at Jellys Ferry, etc.—Cont'd.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet*	*Sec.-feet.*	*Inches*
January	74,240	8,915	20,983	1,290,194	2.30	2.65
February	101,880	9,800	34,138	1,895,928	3.74	3.99
March	46,100	12,200	20,628	1,268,366	2.26	2.61
April	16,700	9,200	10,870	646,810	1.19	1.33
May	13,700	7,530	9,804	602,824	1.07	1.23
June	7,265	4,965	5,596	332,985	.61	.68
July	4,760	3,980	4,365	268,393	.48	.55
August	3,980	3,805	3,850	236,727	.42	.48
September	5,380	3,630	3,922	233,375	.43	.48
October	5,380	3,980	4,194	257,879	.46	.53
November	44,100	4,360	7,745	460,859	.85	.94
December	61,800	5,380	12,149	747,013	1.33	1.53
The year	101,880	3,630	11,520	8,241,353	1.26	16.91
1902.						
January	6,750	4,760	5,376	330,557	.59	.68
February	151,320	5,660	69,153	3,840,563	7.44	7.75
March	61,700	14,150	27,371	1,682,977	2.94	3.39
April	53,800	14,150	21,992	1,308,615	2.37	2.64
May	24,460	10,150	17,803	1,094,663	1.92	2.21
June	13,450	7,060	9,998	594,922	1.08	1.20
July	7,060	5,880	6,192	380,731	.67	.77
August	5,880	5,440	5,674	348,881	.61	.70
September	5,220	5,000	5,007	297,938	.54	.60
October	11,750	5,000	5,931	364,683	.64	.74
November	118,200	5,660	19,834	1,180,204	2.13	2.38
December	39,100	8,110	17,506	1,076,402	1.88	2.17
The year	151,320	4,760	17,653	12,501,135	1.90	25.2

Discharge measurement of Upper Sacramento River, Shasta County, 1 mile above junction with Pitt River.

Date.	Hydrographer.	Gage height.	Discharge
1901.		*Feet.*	*Sec.-feet*
Sept. 10	S. G. Bennett		21

Discharge measurements of Sacramento River.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
1902.		*Feet.*	*Sec.-feet.*	
Sept. 22	Charles A. Miller		384	Castle Crags, Shasta County.
Do	S. G. Bennett		286	Bards Station, Shasta County.
Do	Charles A. Miller		15	Soda Creek at Castle Crags, Shasta County.
Sept. 14	do		4,455	Balls Ferry, Tehama County.
Sept. 15	do		313	Battle Creek, near Balls Ferry, Tehama County.
Do	do		27	Ditch from Battle Creek, near Balls Ferry, Tehama County.
	Total		340	
Sept. 26	S. G. Bennett	7.22	5,848	Sacramento, Sacramento County.

SALINAS RIVER.

Salinas River rises in San Luis Obispo County, flows in a northwesterly direction through Salinas Valley, and discharges into the Bay of Monterey. The crest of the Coast Range, locally known as the Santa Lucia Mountains, forms the boundary of the watershed on the south and west; the crest of the Gabilan Mountains and the Mount Diablo Range forms the eastern boundary of the watershed. The total area drained is 4,780 square miles. The principal tributaries of the river, Nacimiento and San Antonio creeks and Arroyo Seco, drain the eastern slopes of the Santa Lucia Mountains. The only important stream entering from the east is San Lorenzo Creek, which drains the western slopes of the Mount Diablo Range.

A reconnaissance survey for reservoir sites on Salinas River and its tributaries was made during the period from May 28 to August 31, 1900, under the direction of Prof. Charles D. Marx, of Stanford University. These studies were continued by Mr. Homer Hamlin during the years 1901 and 1902, and the results are being prepared for publication.

A gaging station was established on the river January 8, 1900, by D. A. Porter. On account of the shifting nature of the channel during floods, four gage rods were set between January 8 and April 2, 1900, and each was referred to a different datum. On June 8, 1900, a permanent station was established at the county bridge, 3¾ miles south of Salinas. The gage, which is vertical, is attached to one of the piers of the bridge. The bench mark is a nail in the washer in the top of a redwood post, 13 inches by 15 inches in size, on the north bank of the river, at an elevation of 20 feet above gage datum.

On account of the continual shifting of the stream bed and the improbability of its water being used for either power or irrigation purposes, the record on this stream was discontinued August 3, 1901.

Discharge measurements of Salinas River, near Salinas, Monterey County.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1900.		*Feet.*	*Sec.-feet.*	
Apr. 9	S. G. Bennett	4.20	25.51	
Apr. 9	D. A. Porter	4.20	26.04	
Apr. 12	do	4.15	15.44	Strong wind upstream.
Apr. 15	do	4.10	13.10	Do.
Apr. 19	do	4.10	17.04	No wind.
Apr. 22	do	4.25	33.85	Do.
Apr. 25	do	4.15	18.91	Strong wind upstream.
May 1	do	4.10	18.02	No wind.
May 4	do	4.10	16.40	Do.
May 7	do	4.10	17.50	Do.
May 12	do	4.10	17.85	Do.
May 16	do	4.10	17.94	Light wind.
May 19	do	4.10	16.23	Do.
May 24	do	4.1	17.20	No wind.
May 29	do	4.1	17.43	Do.
June 2	do	4.05	13.32	Windy.
June 5	do	4.05	15.29	No wind.
June 8	do	4.0	14.05	Do.
June 12	do	4.05	15.79	Do.
June 15	do	4.05	15.32	Light wind.
June 18	do	4.0	13.93	Do.
June 22	do	4.0	12.91	No wind.
June 26	do	4.0	11.47	Light wind upstream.
June 30	do	3.9	10.50	No wind.
July 3	do	3.65	9.96	Fresh wind upstream.
July 16	do	3.70	9.56	No wind.
Aug. 1	do	3.70	9.83	Do.
Aug. 18	do	3.65	9.88	Light breeze downstream
Sept. 1	do	3.65	10.10	No wind.
Sept. 26	S. G. Bennett	3.45	1.7	
Oct. 23	J. B. Lippincott	3.45	1.7	
Oct. 26	W. W. Cockins, jr		1.1	1 mile below sugar factory.
Nov. 14	do	3.7	8.6	
Nov. 16	do	4.2	31.6	
Nov. 19	do	6.7	2,056	
Nov. 20	do	5.9	829	
Nov. 21	do	5.6	743	
Nov. 22	do	15.6	33,600	Float.
Nov. 23	do	9.7	12,851	Do.

Discharge measurements of Salinas River, near Salinas, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1901.		*Feet.*	*Sec.-feet.*	
Jan. 15	S. G. Bennett	6.8	2,142	
Jan. 22	do	5.8	1,338	
Jan. 24	W. W. Cockins, jr	5.9	1,598	
Feb. 9	S. G. Bennett	7.9	4,982	
Feb. 19	do	6.05	1,561	
Apr. 12	W. W. Cockins, jr	4.7	342	
Mar. 17	do	5.6	1,204	
Mar. 24	do	5.2	668	
Mar. 30	do	4.9	541	
Apr. 6	do	4.75	512	

Estimated monthly discharge of Salinas River at a point 4 miles south of Salinas, Monterey County.

[Drainage area, 4,084 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1900.						
January 8 to 31	2,700	223	848	40,368	0.21	0.19
February	223	40	105	5,831	.03	.03
March	223	25	73	4,489	.02	.02
April	32	19	22	1,309	.01	.01
May	19	17	17	1,045	.00	.00
June	17	15	16	952	.00	.00
July	10	6	8	492	.00	.00
August	8	6	7	430	.00	.00
September	8	2	6	357	.00	.00
October	4	1	2	123	.00	.00
November	33,600	0	2,413	143,583	.59	.66
December	1,050	82	295	18,139	.07	.08
The year	33,600	0	318	217,118	.08	.99

Estimated monthly discharge of Salinas River, etc.—Continued.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1901.						
January	35,162	380	4,921	302,580	1.21	1.39
February	20,927	540	4,172	231,701	1.02	1.07
March	1,772	430	1,063	65,361	.26	.30
April	405	160	270	16,066	.07	.07
May	2,012	160	533	32,773	.13	.15
June	160	30	56	3,332	.01	.02
July	30	25	27	1,660	.01	.01

Discharge measurements of Salinas River at bridge, Bradley, Monterey County

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Second-feet.*
Feb. 14	S. G. Bennett		1,433

TRIBUTARIES OF SALINAS RIVER.

ARROYO SECO.

This stream rises on the eastern slope of the Santa Lucia Mountains, flows eastward, and empties into Salinas River at Soledad, Cal. A gaging station was established December 30, 1900, by W. W. Cockins, jr., at Foster's ranch, near Piney, Cal. The high water of January, 1901, enlarged the old channel, and the gaging station was removed to Pettit's ranch, 4 miles below.

The purpose of establishing these gaging stations was to get the maximum flood discharge and the amount of water available for storage.

The total area of watershed drained above Pettit's ranch is 21 square miles.

Discharge measurements of Arroyo Seco, a tributary of Salinas River.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
1900.		*Feet.*	*Sec.-feet.*	
June 20, 2.30 p. m.	D. A. Porter		11.78	First pool above entrance of Santa Lucia, Monterey County.
June 20, 3.10 p. m.	do		12.42	Between second and third pools above entrance of Santa Lucia, Monterey County, Cal.
June 21, 8 a. m.	do		10.40	Road crossing of stream between Moor's and Abbott's houses, Monterey County, Cal.
June 21, 3.20 p. m.	do		7.30	200 feet above Currier's dam site, Monterey County, Cal.
June 21, 4.55 p. m.	do		6.14	50 feet below head gate Salina Valley Water Co.'s Arroyo Seco ditch No. 2. Canal was taking all water of creek on this date.
1901.				
Feb. 11	S. G. Bennett	3.70	535	Point near Foster's, Monterey County, Cal.
Mar. 26	W. W. Cockins, jr.		162	Do.
Apr. 2	do	5.8	105	Pettitt's Ranch, Monterey County, Cal.
July 10	Homer Hamlin	5.3	23	Do.
Sept. 24	do		7.9	Do.
Nov. 6	H. E. Green	5.2	15	Do.
1902.				
Feb. 24	S. G. Bennett	8.2	[a]1,720	
Feb. 25	do	11.7	[a]7,883	
Feb. 26	do	9	[a]2,777	
Apr. 29	do	5.75	144	
July 18	Homer Hamlin	5.08	10.4	
Aug. 7	do	4.9	2.3	

[a] Float measurements.

Estimated monthly discharge of Arroyo Seco, a tributary of Salinas River at Piney, Monterey County.

[Drainage area, 215 square miles.]

Month.	Discharge.			Run-off		
	Maximum.	Minimum.	Mean.	Total discharge.	Per square mile.	Depth.
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	4,500	105	888	54,601	4.13	4.76
February	2,860	160	931	51,705	4.33	4.81
March	610	105	246	15,126	1.14	1.31
April	2,500	95	195	11,603	.91	1.01
May			95	5,841	.44	.51
June			58	3,451	.27	.30
July			22	1,353	.10	.11
August			15	922	.07	.08
September			8	476	.04	.04
October			10	615	.05	.06
November			22	1,309	.10	.11
December			26	1,599	.12	.14
The year			209	148,601	.98	13.56
1902.						
January	40	25	28	1,722	.13	.15
February	2,860	25	605	33,600	2.81	2.93
March	2,320	185	620	38,122	2.88	3.32
April	1,650	145	270	16,066	1.26	1.40
May	105	55	74	4,550	.34	.39
June	55	15	32	1,904	.15	.17
July	15	7	12	738	.06	.07
August	7	3	4	246	.02	.02
September	3	0	0	0	.00	.00
October	55	0	9	553	.04	.05
November	750	11	57	3,392	.27	.30
December	145	25	54	3,320	.25	.29
The year	2,860	0	147	104,213	.68	9.27

NACIMIENTO CREEK.

This stream drains the eastern slopes of the Santa Lucia Mountains and enters Salinas River 5 miles above Bradley, Cal. A gaging station was established on this stream at Harris ranch, near Bryson, Cal., by S. G. Bennett, on February 17, 1901. The record on this stream was discontinued April 30, 1901. The total area drained above the gaging station is 171 square miles.

Discharge measurements of Nacimiento Creek, a branch of Salinas River, at point near Bryson, Monterey County.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Sec.-feet.*
Feb. 17	S. G. Bennett	6.15	284
Mar. 25	W. W. Cockins, jr	5.3	105
Apr. 8	do	5.3	121

Discharge measurements of Nacimiento Creek, a branch of Salinas River, near Newhall Ranch house, San Migulito ranch, Monterey County.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Sec.-feet.*
Jan. 18	S. G. Bennett	6.1	106
Feb. 13	do	6.5	169
June 3	H. Hamlin	4.82	33
July 12	do	4.42	3.8

Estimated monthly discharge of Nacimiento Creek, a tributary of Salinas River, at Bryson, Monterey County.

[Drainage area, 171 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
	Sec.-feet.	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
February 17 to 28	3,300	295	855	20,350	5.00	5.21
March	365	110	184	11,314	1.08	1.24
April	670	87	99	5,891	.58	.65

Discharge measurements of Nacimiento Creek, a tributary of Salinas River, 4 miles above mouth, San Luis Obispo County.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Sec.-feet.*
Feb. 15	S. G. Bennett		527

BURNETT CREEK.

Discharge measurements of Burnett Creek, tributary of Nacimiento Creek, branch of Salinas River, San Luis Obispo County.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Sec.-ft.*
Apr. 4	W. W. Cockins, jr		2

SAN ANTONIO CREEK.

This stream drains the eastern slopes of the Santa Lucia Mountains and enters the Salinas River at Bradley, Cal. A gaging station was established near Jolon, Cal., December 15, 1900, by W. W. Cockins, jr. The total area drained is 161 square miles. The record on this stream was discontinued April 30, 1901.

Discharge measurements of San Antonio Creek, Salinas River, near Jolon, Monterey County.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Sec.-ft.*
Jan. 19	S. G. Bennett	4.45	185
Feb. 12	do	4.8	242
Mar. 18	W. W. Cockins, jr	4.5	148
Mar. 26	do	4.3	76
Apr. 5	do	4.3	76
Apr. 18	do	4.1	59
July 11	H. Hamlin		64

Discharge measurement of San Antonio Creek, Salinas River, Los Ojitos Dam site, Monterey County.

Date.	Hydrographer.	Gage height	Discharge.
1901.		*Feet.*	*Sec.-ft.*
Apr. 17	J. B. Lippincott		9

Discharge measurement of San Antonio Creek, Salinas River, Pinkerton Dam site, Monterey County.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet*	*Sec.-ft.*
Apr. 17	J. B. Lippincott		7

Estimated monthly discharge of San Antonio Creek, a tributary of Salinas River, at Jolon, Monterey County.

[Drainage area, 161 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1900.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
December 15 to 28	200	170	184	5,109	1.14	0.59
1901.						
January	3,700	64	523	32,158	3.25	3.75
February	1,700	110	509	28,268	3.17	3.31
March	400	84	171	10,514	1.06	1.22
April	740	39	83	4,939	.52	.58

SAN LORENZO CREEK.

This stream drains the western slopes of the Gavilan Mountains and enters the Salinas River near Kings City, Cal. There is a reservoir and dam site on the stream 5 miles above its mouth. The stream is entirely dry during the summer months. The flood waters are used for winter irrigation. A gaging station was established December 16, 1900, by W. W. Cockins, jr., at Hollenbeck's ranch, a quarter of a mile below the dam site.

The area of the watershed drained is 235 square miles.

Discharge measurements of San Lorenzo Creek, Salinas River, at dam site, 5 miles above King City, Monterey County.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
1901.		*Feet.*	*Sec.-feet.*	
Jan. 22	S. G. Bennett	4.98	28.7	Near Hollenbeck ranch house.
Feb. 14	do	5.3	71.2	Do.
Mar. 27	W. W. Cockins, jr	4.3	12.6	Do.
Apr. 1	do	4.2	5.1	Do.
Apr. 15	do	4.1	2.1	Do.
Nov. 2	H. E. Green	.9	2.8	Near Mathews ranch house.
1902.				
Jan. 24	S. G. Bennett	.9	4.6	Do.
Feb. 24	do	1.09	43.0	Do.
Apr. 30	do	.9	1.8	Do.
July 16	Homer Hamlin		.08	Do.

Estimated monthly discharge of San Lorenzo Creek, a tributary of Salinas River at King City, Monterey County.

[Drainage area, 235 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1900.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
December 16 to 31	13	9	9	286	0.04	[illegible]
1901.						
January	2,540	9	171	10,514	.73	[illegible]
February	9,200	9	725	40,264	3.09	[illegible]
March	27	9	17	1,045	.07	[illegible]
April	13	6	8	476	.03	[illegible]

Estimated monthly discharge of San Lorenzo Creek at King City.

[Drainage area, 235 square miles.]

Month.	Discharge.			Total discharge.	Run-off	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1902.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	15	5	6	369	.03	[illegible]
February	795	5	69	3,832	.29	[illegible]
March	875	5	81	4,980	.34	[illegible]
April	5	3	4	238	.02	[illegible]
November	200	15	85	5,057	.36	[illegible]
December	15	5	7	430	.03	

SALT SPRING VALLEY.

Estimated seasonal discharge into Salt Spring Valley reservoir near Milton, Calaveras County, Cal.[a]

[Drainage area, 25 square miles.]

Year.	Mean discharge.	Total for year.	Run-off.		Rainfall	Run-off
			Per square mile.	Depth.		
	Sec.-feet.	*Acre-feet.*	*Sec.-feet.*	*Inches.*	*Inches.*	*Per cent.*
1889–90	36.7	26,606	1.47	19.95	30.38	[illegible]
1890–91	6.3	4,591	.25	3.39	13.06	[illegible]
1891–92	4.9	3,560	.20	2.71	16.98	[illegible]
1892–93	30.8	22,311	1.23	16.69	26.46	[illegible]
1893–94	22.5	16,323	.90	12.21	25.37	[illegible]
1894–95	35.4	25,664	1.42	19.27	32.31	[illegible]
1895–96	8.5	6,221	.34	4.61	23.98	[illegible]
Mean	20.7	15,099	.83	11.26	24.08	[illegible]

[a] Evaporation not considered in this table.

SAN ANTONIO CREEK.

The discharge of the streams of southern California was unusually low in September, 1898, and these measurements were made by the Edison Electric Company to determine the minimum with its hourly fluctuation.

Discharge measurements of San Antonio Creek, at Water Company's weir, San Bernardino County.

[Measurements by Edison Electric Co.]

Date.	Discharge.
September 15, 1898:	*Sec.-feet.*
7 a. m	5.60
7.30 a. m	5.60
8 a. m	5.60
8.30 a. m	5.60
9 a. m	5.58
9.30 a. m	5.58
10 a. m	5.58
10.30 a. m	5.44
11 a. m	5.32
11.30 a. m	5.32
12 m	5.32
12.30 p. m	5.32
1 p. m	5.06
1.30 p. m	5.06
2 p. m	5.06
2.30 p. m	5.06
3 p. m	4.94
3.30 p. m	4.94
4 p. m	4.94
4.30 p. m	4.80
5 p. m	4.80
5.30 p. m	4.80
6 p. m	4.92
6.30 p. m	5.06
12-hour mean	5.22
September 15, 1898:	
7 p. m	5.06
7.30 p. m	5.06
8 p. m	5.06
8.30 p. m	5.44
9 p. m	5.44
9.30 p. m	5.60
10 p. m	5.60
10.30 p. m	5.60
11 p. m	5.60
11.30 p. m	5.70
12 midnight	5.70
September 16, 1898:	
12.30 a. m	5.70
1 a. m	5.70
1.30 a. m	5.70
2 a. m	5.70
2.30 a. m	5.70
3 a. m	5.70
3.30 a. m	5.70
4 a. m	5.70
4.30 a. m	5.70
5 a. m	5.70
5.30 a. m	5.70
6 a. m	5.60
6.30 a. m	5.60
12-hour mean	5.57
September 16, 1898:	
7 a. m	5.60
7.30 a. m	5.60
8 a. m	5.60
8.30 a. m	5.60
9 a. m	5.60
9.30 a. m	5.60
10 a. m	5.44

Discharge measurements of San Antonio Creek, etc.—Continued.

Date.	Discharge.
	Sec.-feet.
September 16, 1898—Cont'd.	
10.30 a. m	5.20
11 a. m	5.18
11.30 a. m	5.06
12 m	5.06
12.30 p. m	4.94
1 p. m	4.94
1.30 p. m	5.06
2 p. m	5.06
2.30 p. m	5.06
3 p. m	5.06
3.30 p. m	4.80
4 p. m	4.80
4.30 p. m	4.56
5 p. m	5.06
5.30 p. m	5.06
6 p. m	5.06
6.30 p. m	4.92
12-hour mean	5.16
September 16, 1898:	
7 p. m	5.06
7.30 p. m	5.06
8 p. m	5.06
8.30 p. m	5.06
September 16, 1898—Cont'd.	
9 p. m	[illegible]
9.30 p. m	[illegible]
10 p. m	[illegible]
10.30 p. m	[illegible]
11 p. m	[illegible]
11.30 p. m	[illegible]
12 midnight	[illegible]
September 17, 1898:	
12.30 a. m	[illegible]
1 a. m	[illegible]
1.30 a. m	[illegible]
2 a. m	[illegible]
2.30 a. m	[illegible]
3 a. m	[illegible]
3.30 a. m	[illegible]
4 a. m	[illegible]
4.30 a. m	[illegible]
5 a. m	[illegible]
5.30 a. m	[illegible]
6 a. m	[illegible]
6.30 a. m	[illegible]
12-hour mean	[illegible]

Discharge measurements of San Antonio Creek, San Bernardino County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
July 23, 1896	J. H. Quinton	7.9	Mouth of canyon.
July 2, 1898	F. H. Olmsted	6.59	Do.
Aug. 26, 1898	do	5.18	Division weir.
Aug. 25, 1899	S. G. Bennett	4.48	Mouth of canyon.
July 11, 1900	do	4.07	Do.
Sept. 25, 1900	W. W. Cockins, jr	3.72	Division weir.
April 3, 1902	S. G. Bennett	11.40	Do.
July 23, 1896	J. H. Quinton	1.88	Ontario water from tunnel.
July 2, 1898	F. H. Olmsted	8.36	In creek at Pierce's camp.

The water of San Antonio Creek is utilized to a large extent. The Pacific Electric Light and Power Company, commonly called the San Gabriel Electric Company, has a power plant in the canyon at an elevation of 3,250 feet. The water from the tailrace of this power house passes over a measuring weir and is discharged into the pipe line of the San Antonio Water Company's power plant. It is carried in this conduit on the right bank of the canyon to a point opposite the old division weir between the San Antonio Water Company and the Pomona Land and Water Company, from which point it is discharged through the power house of the San Antonio Water Company. The portion of the water which goes to the San Antonio Water Company is again diverted through a pipe line and used at a third power house, at an elevation of about 1,900 feet, near the left bank of the canyon. In addition there is a tunnel in the mouth of the canyon run through the bowlders and gravels of the river bed to bed rock, up to and near the old division box mentioned above. This tunnel water together with all other water after it has been used for power is used for irrigation near Ontario and Pomona.

The second power plant on the river was constructed by the San Antonio Water Company during the year 1902, and before the water was diverted into the conduits of this corporation a board of engineers was appointed by the San Antonio Water Company to make measurements of the water in various portions of the canyon in order to determine what effect, if any, would result from the diversion of the stream which they contemplated from the upper power house of the San Gabriel Electric Company to the old division box. This board of engineers consisted of W. H. Saunders, chief engineer, F. E. Trask, Samuel Storrow, and J. B. Lippincott, consulting engineer. Suitable weirs were erected, and automatic river-height-recording devices were installed on most of these weirs. The San Gabriel Electric Company's power-house weir was located in the tailrace of the power house, and measured the main volume of water in the river at that point. The "Fountain of Life" spring is a small steady flow of water issuing from a spring near the San Gabriel Electric Company's power house, but the water is not included in that measured in the power-house weir. A small amount of water was flowing in the bed of the stream opposite the San Gabriel Electric Company's power house, and was not included in either the power-house weir or the "Fountain of Life" spring measurements.

The Spring Hill weir was located in the main river below the San Gabriel Electric Company's power house and measured total flow.

The "Baby Ruth" weir was also in the main stream below the San Gabriel Electric Company's power house, and above the division weir, and measured the full stream.

The division weir was located in the main stream opposite the power house of the San Antonio Water Company. At this point the

water is divided between the San Antonio Water Company and the Pomona Land and Water Company, but before the division occurs a certain amount of water, known as gird water, is taken out of the stream and not included in the measurement of the main division weir.

The water measured in the San Antonio tunnel is picked up from the sands and gravels of the river bed below all the above-mentioned points of measurements, and this water is not included in any other measurement.

All these measurements were made prior to the time when the diversion occurred through the new pipe line and power plant of the San Antonio Water Company.

All these measurements were made for the San Antonio Water Company by the engineers in question. They were supplemented by further continuous records obtained from the automatic registers but these records are not now available for publication.

Discharge measurements of San Antonio Creek.

Date.	Hydrographer.	Discharge.	Locality.
1902.		*Sec.-feet.*	
June 28	J. B. Lippincott	7.69	Baby Ruth weir.
July 12, 11.40 a. m	do	6.88	Do.
July 12, 1.13 p. m	do	6.58	Do.
Aug. 2, 11.15 a. m	do	6.15	Do.
Aug. 9, 11 a. m	do	6.15	Do.
Aug. 9, 1.12 p. m	do	5.99	Do.
Aug. 29, 11.45 a. m	do	5.61	Do.
Sept. 29, 12.30 p. m	do	4.88	Do.
Oct. 18, 12.30 p. m	do	4.74	Do.
June 28	do	6.56	Division weir.
Do	do	.42	Gird water.
		6.98	Total.
July 12, 10.58 a. m	do	5.76	Division weir.
Do	do	.35	Gird water.
		6.11	Total.
July 12, 2.40 p. m	do	5.20	Division weir.
Do	do	.35	Gird water.
		5.55	Total.

Discharge measurements of San Antonio Creek—Continued.

Date.	Hydrographer.	Discharge.	Locality.
1902.		*Sec.-feet.*	
Aug. 2, 10.30 a. m	J. B. Lippincott	4.83	Division weir.
Do	do	.36	Gird water.
		5.19	Total.
Aug. 2, 2.30 p. m	do	4.35	Division weir.
Do	do	.36	Gird water.
		4.71	Total.
Aug. 9, 10.18 a. m	do	4.76	Division weir.
Do	do	.35	Gird water.
		5.11	Total.
Aug. 9, 2.40 p m	do	4.18	Division weir.
Do	do	.35	Gird water.
		4.53	Total.
Aug 29. 10.55 a. m	do	4.26	Division weir.
Do	do	.38	Gird water.
		4.64	Total.
Aug. 29, 2.27 p. m	do	3.55	Division weir.
Do	do	.38	Gird water.
		3.93	Total.
Sept. 27, 10.30 a. m	do	4.00	Division weir.
Do	do	.33	Gird water.
		4.33	Total.
Sept. 27, 2.15 p. m	do	3.57	Division weir.
Do	do	.33	Gird water.
		3.90	Total.
Oct. 18, 10.55 a. m	do	3.98	Division weir.
Do	do	.38	Gird water.
		4.36	Total.
June 28	do	.34	Fountain of Life spring—weir measurement.
July 12, 12.15 p. m	do	.34	Do.
Aug. 2, 12.05 p. m	do	.30	Do.

Discharge measuremeuts of San Antonio Creek—Continued.

Date.	Hydrographer.	Discharge.	Locality.
1902.		*Sec.-feet.*	
Aug. 9, 11.42 a. m	J. B. Lippincott	0.32	Fountain of Life spring—weir measurement.
Aug. 29, 12.20 p. m	do	.29	Do.
Sept. 27, 11.33 a. m	do	.29	Do.
Oct. 18, 12 m	do	.30	Do.
June 28	do	1.38	San Antonio tunnel—weir measurement.
July 12, 10.36 a. m	do	1.27	Do.
Aug. 2, 10.10 a. m	do	1.19	Do.
Aug. 9, 10 a. m	do	1.17	Do.
Aug. 30, 10.30 a. m	do	1.15	Do.
Sept. 27, 10.12 a. m	do	1.12	Do.
June 28	do	7.40	San Gabriel Electric Company's power house—concrete weir basin—weir measurement.
July 12, 12.20 p. m	do	6.10	Do.
Aug. 2, 12 m	do	5.59	Do.
Aug. 9, 11.48 a. m	do	5.67	Do.
Aug. 29, 12.30 p. m	do	4.59	Do.
Sept. 27, 11.37 a. m	do	4.64	Do.
Oct. 13, 11.38 a. m	do	4.31	Do.
June 28	do	.55	San Gabriel Electric Company's power house—weir measurement in creek.
July 12, 12.33 p. m	do	.47	Do.
Aug. 2, 12.10 p. m	do	.40	Do.
Aug. 9, 12.11 p. m	do	.40	Do.
Aug. 29, 12.40 p. m	do	.35	Do.
Sept. 27, 12 m	do	.36	Do.
Oct. 18, 12 m	do	.39	Do.
Aug. 2, 11.45 a. m	do	6.31	Spring Hill weir.
Aug. 9, 11.22 a. m	do	6.36	Do.
Aug. 9, 1 p. m	do	5.88	Do.
Aug. 29, 12.07 p. m	do	5.59	Do.
Aug. 29, 12.10 p. m	do	5.40	Do.
Sept. 27, 12.05 p. m	do	5.28	Do.
Oct. 18, 12.12 p. m	do	5.01	Do.

SAN BERNARDINO VALLEY.

ischarge measurements of San Bernardino Valley, between San Bernardino and Riverside.

Date.	Discharge.	Locality.
	Sec.-feet.	
une, 1898	0.61	Developed water, Camp Carlton ditch.
eptember, 1898	1.20	Do.
[arch, 1899	2.13	Do.
une, 1899	1.63	Do.
ugust, 1899	1.02	Do.
[arch, 1900	2.55	Do.
une, 1900	2.60	Do.
eptember, 1900	1.67	Do.
ctober 7, 1902	1.70	Do.
une, 1898	.67	Beams ditch, natural water.
eptember, 1898	.65	Do.
[arch, 1899	.72	Do.
une, 1899	.52	Do.
ugust, 1899	.40	Do.
[arch, 1900	.68	Do.
une, 1900	.50	Do.
eptember, 1900	.33	Do.
ctober 13, 1902	.22	Do.
une, 1898	5.26	Bloomington flume, developed water.
eptember, 1898	5.49	Do.
[arch, 1899	.00	Do.
une, 1899	5.93	Do.
ugust, 1899	3.05	Do.
[arch, 1900	3.80	Do.
une, 1900	3.68	Do.
eptember, 1900	3.28	Do.
ctober 7, 1902	2.28	Do.
une, 1898	6.82	City of Colton ditch, developed water.
eptember, 1898	7.40	Do.
[arch, 1899	3.20	Do.
une, 1899	5.49	Do.
ugust, 1899	3.89	Do.
[arch, 1900	4.94	Do.
une, 1900	3.21	Do.
eptember, 1900	3.54	Do.
ctober 7, 1902	3.53	Do.
une, 1898	1.97	Colton Terrace Water Co., developed water.
eptember, 1898	1.61	Do.

Discharge measurements of San Bernardino Valley, etc.—Continued.

Date.	Discharge.	Locality.
	Sec.-feet.	
March, 1899	1.69	Colton Terrace Water Co., developed water.
June, 1899	1.30	Do.
August, 1899	1.30	Do.
March, 1900	1.69	Do.
June, 1900	1.54	Do.
September, 1900	1.53	Do.
October 7, 1902	1.08	Do.
June, 1898	.63	Daley ditch, natural water.
September, 1898	.67	Do.
March, 1899	.71	Do.
June, 1899	.51	Do.
August, 1899	.51	Do.
March, 1900	.72	Do.
June, 1900	1.12	Do.
September, 1900	.54	Do.
October 13, 1902	.00	Do.
June, 1898	4.40	East Riverside district, or Riverside Highlands Water Co., developed water.
September, 1898	4.43	Do.
March, 1899	4.25	Do.
June, 1899	2.08	Do.
August, 1899	2.00	Do.
March, 1900	6.59	Do.
June, 1900	5.38	Do.
September, 1900	3.70	Do.
June, 1898	1.16	Gage canal, Santa Ana River, natural water.
September, 1898	1.16	Do.
March, 1899	.72	Do.
June, 1899	.24	Do.
August, 1899	.64	Do.
March, 1900	.395	Do.
June, 1900	.29	Do.
September, 1900	.17	Do.
October 7, 1902	.00	Do.
June, 1898	26.26	Gage canal, Palm avenue weir, developed water.
September, 1898	25.07	Do.
March, 1899	26.68	Do.
June, 1899	25.22	Do.
August, 1899	23.47	Do.
March, 1900	21.96	Do.
June, 1900	22.23	Do.

Discharge measurements of San Bernardino Valley, etc.—Continued.

Date.	Discharge	Locality.
	Sec.-feet.	
September, 1900	27.85	Gage canal, Palm avenue weir, developed water.
October 11, 1902	30.17	Do.
June, 1898	.84	Haws and Talmadge ditch, natural water.
September, 1898	.00	Do.
March, 1899	.28	Do.
June, 1899	.00	Do.
August, 1899	.00	Do.
March, 1900	.00	Do.
June, 1900	.00	Do.
September, 1900	.00	Do.
September 30, 1902	.00	Do.
June, 1898	.72	Logsdon and Farrell ditch, natural water.
September, 1898	.63	Do.
March, 1899	1.61	Do.
June, 1899	1.15	Do.
August, 1899	.54	Do.
March, 1900	1.26	Do.
June, 1900	.49	Do.
September, 1900	.20	Do.
October 13, 1902	.00	Do.
June, 1898	.37	McIntyre ditch, natural water.
September, 1898	.038	Do.
March, 1899	.82	Do.
June, 1899	.15	Do.
August, 1899	.00	Do.
March, 1900	.14	Do.
June, 1900	.01	Do.
September, 1900	.00	Do.
October 7, 1902	.00	Do.
June, 1898	2.54	McKenzie ditch, natural water.
September, 1898	2.08	Do.
March, 1899	9.40	Do.
June, 1899	3.86	Do.
August, 1899	2.00	Do.
March, 1900	2.30	Do.
June, 1900	1.57	Do.
September, 1900	1.69	Do.
September 30, 1902	.00	Do.
June, 1898	8.42	Meeks and Daley ditch, natural water.
September, 1898	17.00	Do.

Discharge measurements of San Bernardino Valley, etc.—Continued.

Date.	Discharge.	Locality.
	Sec. feet.	
March, 1899	17.00	Meeks and Daley ditch, natural water.
June, 1899	15.48	Do.
August, 1899	10.45	Do.
March, 1900	13.94	Do.
June, 1900	13.78	Do.
September, 1900	14.68	Do.
September 30, 1902	13.40	Do.
June, 1898	1.94	Mill pump, developed water.
September, 1898	2.04	Do.
March, 1899	.00	Not running.
June, 1899	1.77	Mill pump, developed water.
August, 1899	1.67	Do.
March, 1900	.00	Not running.
June, 1900	1.88	Mill pump, developed water.
September, 1900	1.52	Do.
September 30, 1902	1.20	Do.
June, 1898	5.37	Rabel dam ditch, natural water.
September, 1898	3.07	Do.
March, 1899	2.26	Do.
June, 1899	1.54	Do.
August, 1899	.94	Do.
March, 1900	.54	Do.
June, 1900	.35	Do.
September, 1900	.07	Do.
September 30, 1902	.00	Do.
June, 1898	1.75	Ranchero ditch, natural water.
September, 1898	1.64	Do.
March, 1899	1.64	Do.
June, 1899	1.00	Do.
August, 1899	.41	Do.
March, 1900	.24	Do.
June, 1900	.55	Do.
September, 1900	1.33	Do.
Do	.80	Ranchero ditch, developed water.
June, 1898	3.12	Riverside Water Company, natural water.
September, 1898	3.36	Do.
March, 1899	5.30	Do.
June, 1899	7.29	Do.
August, 1899	2.56	Do.
March, 1900	2.67	Do.

Discharge measurements of San Bernardino Valley, etc.—Continued.

Date.	Discharge.	Locality.
	Sec.-feet.	
June, 1900	2.17	Riverside Water Company, natural water.
September, 1900	.94	Do.
September 30, 1902	.50	Do.
June, 1898	2.30	Shay or Stout dam ditch, natural water.
September, 1898	2.08	Do.
March, 1899	2.23	Do.
June, 1899	1.13	Do.
August, 1899	.90	Do.
March, 1900	.507	Do.
June, 1900	.40	Do.
September, 1900	.16	Do.
September 30, 1902	.00	Do.
June, 1898	1.00	Swamp ditch, natural water.
September, 1898	1.02	Do.
March, 1899	.85	Do.
June, 1899	.77	Do.
August, 1899	.69	Do.
March, 1900	.70	Do.
June, 1900	.89	Do.
September, 1900	.86	Do.
October 14, 1902	.93	Do.
June, 1898	1.60	Ward and Warren ditch, developed water.
Do	.72	Ward and Warren ditch, natural water.
September, 1898	1.60	Ward and Warren ditch, developed water.
Do	.72	Ward and Warren ditch, natural water.
March, 1899	1.60	Ward and Warren ditch, developed water.
Do	1.49	Ward and Warren ditch, natural water.
June, 1899	.615	Ward and Warren ditch, developed water.
August, 1899	1.56	Do.
March, 1900	1.60	Do.
Do	.95	Ward and Warren ditch, natural water.
June, 1900	1.60	Ward and Warren ditch, developed water.
Do	.10	Ward and Warren ditch, natural water.
September, 1900	.53	Ward and Warren ditch, developed water.
October 14, 1902	.30	Do.
Do	1.58	Ward and Warren ditch, natural water.
June, 1898	.26	Whiting ditch, natural water.
September, 1898	.01	Do.
March, 1899	.76	Do.
June, 1899	.246	Do.

Discharge measurements of San Bernardino Valley, etc.—Continued.

Date.	Discharge.	Locality.
	Sec.-feet.	
August, 1899	0.01	Whiting ditch, natural water.
March, 1900	1.12	Do.
June, 1900	.13	Do.
September, 1900	.00	Do.
October 13, 1902	.00	Do.
June, 1898	.34	Whitlock ditch, natural water.
September, 1898	.38	Do.
March, 1899	.47	Do.
June, 1899	.28	Do.
August, 1899	.09	Do.
March, 1900	.23	Do.
June, 1900	.00	Do.
September, 1900	.00	Do.
October 13, 1902	.00	Do.

List of discharge measurements of San Bernardino Valley between San Bernardino and Colton.

Date.	Discharge.	Remarks.
	Sec.-feet.	
June, 1898	18.00	Riverside Water Co., upper canal, developed water.
Do	41.04	Riverside Water Co., upper canal, natural water.
September, 1898	17.54	Riverside Water Co., upper canal, developed water.
Do	43.80	Riverside Water Co., upper canal, natural water.
March, 1899	18.04	Riverside Water Co., upper canal, developed water.
Do	42.49	Riverside Water Co., upper canal, natural water.
June, 1899	17.50	Riverside Water Co., upper canal, developed water.
Do	36.42	Riverside Water Co., upper canal, natural water.
August, 1899	27.50	Riverside Water Co., upper canal, developed water.
Do	24.54	Riverside Water Co., upper canal, natural water.
March, 1900	24.54	Riverside Water Co., upper canal, developed water.
Do	37.40	Riverside Water Co., upper canal, natural water.
June, 1900	32.36	Riverside Water Co., upper canal, developed water.
Do	20.58	Riverside Water Co., upper canal, natural water.
September, 1900	27.00	Riverside Water Co., upper canal, developed water.
Do	34.02	Riverside Water Co., upper canal, natural water.
September 30, 1902	26.08	Riverside Water Co., upper canal, developed water.
Do	21.89	Riverside Water Co., upper canal, natural water.

Discharge measurements of return waters below Slover Mountain, above Riverside Narrows, San Bernardino Valley, between San Bernardino and Riverside.

Date.	Discharge.	Remarks.
1902.	*Sec.-feet.*	
September 29	5.94	West Riverside pumping plant, developed water.
October 11	4.38	Rogers pumping plant, developed water.
Do	2.95	Riverside Water Co., pumping plant No. 1, Santa Ana River flume, developed water.
Do	2.08	Riverside Water Co., pumping plant No. 2, Santa Ana River flume, developed water.
September 29	3.07	Riverside Water Co., flume head of lower canal, natural water.
Do	7.19	Roubidoux Canal, natural water.
Do	2.17	Evans ditch at north line Riverside County line, natural water.
Do	.53	Evans ditch 1 mile south Riverside County line, natural water.
Do	5.35	Evans Island ditch, west end of West Riverside bridge, natural water.
Do	1.96	Alvetriz ditch at east end West Riverside bridge, natural water.
October 10	43.25	Santa Ana River at Riverside Narrows.
Total	63.52	

Comparative amounts of water, in second-feet, flowing in canals above Colton.

Name of ditch.	June, 1898.	Sept., 1898.	Mar., 1899.	June, 1899.	Aug., 1899.	Mar., 1900.	June, 1900.	Sept., 1900.	Sept. 1901
Haws & Talmage	0.84	0.00	0.28	0.00	0.00	0.00	0.00	0.00	[illegible]
Rabel dam	5.37	3.07	2.86	1.54	.94	.54	.35	.07	[illegible]
Shay or Stout dam	2.30	2.08	2.23	1.13	.90	.507	.40	.16	[illegible]
McKenzie	2.54	2.08	9.40	3.86	2.00	2.30	1.57	1.69	[illegible]
Meeks & Daley	8.42	[a]17.00	17.00	15.48	10.45	13.94	13.78	14.68	13.[illegible]
Beam	.67	[b].65	.72	.52	.40	.68	.50	.33	[illegible]
Riverside Water Co., upper canal [b]	59.04	61.34	60.53	53.92	52.04	61.94	52.94	61.02	47.[illegible]
Timber	.00	.00	.00	.00	.00	.00	.00	.00	[illegible]
Gage canal, Santa Ana River	1.16	1.16	.72	.24	.64	.395	.29	.17	[illegible]
Gage canal, Palm avenue	[c]26.26	[c]25.07	[c]26.68	[c]25.22	[c]23.47	[c]21.96	[c]22.23	[c]27.85	[illegible]
Logsdon & Farrell	.72	.63	1.61	1.15	.54	1.26	.49	.30	[illegible]
Whitlock	.34	.38	.47	.28	.094	.23	.00	.00	[illegible]
Daley	.63	.67	.71	.51	.51	.72	1.12	.54	[illegible]
McIntyre	.37	.038	.82	.15	.00	.14	.01	.00	[illegible]
Whiting	.26	.01	.76	.246	.01	1.12	.13	.00	[illegible]
Swamp	1.00	1.02	.85	.77	.69	.70	.89	.86	[illegible]
Ranchero	[a]1.75	1.64	1.64	1.00	.41	.24	.55	1.33	[illegible]
Ward & Warren	2.32	[a]2.32	3.09	.615	1.56	2.55	1.70	.53	[illegible]
Mill flume of Riverside Water Co.	3.12	3.36	5.30	7.29	2.56	2.67	2.17	.94	[illegible]
Mill pump of Riverside Water Co.	1.94	2.04	[d]	1.77	1.67	[d]	1.88	1.52	[illegible]
Camp Carlton	.61	1.20	2.13	1.62	1.02	2.55	2.60	1.67	[illegible]
East Riverside	4.40	4.43	4.25	2.08	2.00	6.59	5.38	3.70	[illegible]
Colton Terrace Water Co	1.97	1.61	1.69	1.30	1.30	1.69	1.54	1.53	[illegible]
City of Colton	6.82	7.40	3.20	5.49	3.89	4.94	3.21	3.54	[illegible]
Bloomington flume	5.26	5.49	[d]	5.93	3.05	3.80	3.68	3.28	[illegible]
West Riverside 350-inch pumping plant	------	------	------	------	------	------	------	------	[illegible]
Rogers pumping plant	------	------	------	------	------	------	------	------	[illegible]
Santa Ana River flume; Riverside pumping plants Nos. 1 and 2	------	------	------	------	------	------	------	------	[illegible]
Total	138.11	144.69	146.44	132.11	110.14	131.46	117.41	125.61	[illegible]

[a] Interpolated. [b] Above Slover Mountain. [c] River water not included. [d] Pumps not [illegible]

Return water, natural flow in second-feet, compared with developed water in San Bernardino Valley above Colton.

Name of ditch.	June, 1898.		September, 1898.		March, 1899.		June, 1899.	
	Developed.	Natural.	Developed.	Natural.	Developed.	Natural.	Developed.	Natural.
Haws & Talmage	.....	0.84	.....	0.00	.....	0.28	.....	0.00
Rabel dam	.....	5.37	.....	3.07	.....	2.36	.....	1.54
Shay or Stout dam	.....	2.30	.....	2.08	.....	2.23	.....	1.13
McKenzie	.....	2.54	.....	2.08	.....	9.40	.....	3.86
Beam	.....	.67	.....	.65	.....	.72	.....	.52
Riverside Water Co., upper canal	18.00	41.04	17.54	43.80	18.04	42.49	17.50	36.42
Gage canal, Santa Ana River	.....	1.16	.....	1.16	.....	.72	.....	.24
Gage canal, Palm avenue weir	26.26	.....	25.07	.....	26.68	.....	25.22	.....
Logsdon & Farrell	.....	.72	.....	.63	.....	1.61	.....	1.15
Whitlock	.....	.34	.....	.38	.....	.47	.....	.28
Daley	.....	.63	.....	.67	.....	.71	.....	.51
McIntyre	.....	.37	.....	.038	.....	.82	.....	.15
Whiting	.....	.26	.....	.010	.....	.76	.....	.246
Swamp	.....	1.00	.....	1.020	.....	.85	.....	.77
Ranchero	.....	[a]1.75	.....	1.640	.....	1.64	.....	1.00
Ward & Warren	1.60	.72	1.60	.720	1.60	1.49	.615	.....
Mill flume of Riverside Water Co	.....	3.12	.....	3.360	.....	5.30	.....	7.29
Mill pump of Riverside Water Co	1.94	.....	2.04	.....	Not run.	.....	1.77	.....
Camp Carlton ditch	.61	.....	1.20	.....	2.13	.....	1.62	.....
East Riverside district, or Riverside Highland Water Co	4.40	.....	4.43	.....	4.25	.....	2.08	.....
Colton Terrace Water Co	1.97	.....	1.61	.....	1.69	.....	1.30	.....
City of Colton pumping plant	6.82	.....	7.40	.....	3.20	.....	5.49	.....
Bloomington flume	5.26	.....	5.49	.....	.00	.....	5.93	.....
Meeks & Daley ditch	.....	8.42	.....	[a]17.00	.....	17.00	.....	15.48
Total	66.86	71.25	66.38	78.31	57.59	88.85	61.525	70.59

[a] Interpolated.

Return water, natural flow in second-feet, etc.—Continued.

Name of ditch.	August, 1899.		March, 1900.		June, 1900.		September, 1900.		September, 1902	
	Developed.	Natural.	Developed.	Natural.	Developed.	Natural.	Developed.	Natural.	Developed.	Natural.
Haws & Talmage		0.00		0.000	0.00	0.00		0.00		
Rabel dam		.94		.540		.35		.07		
Shay or Stout dam		.90		.507		.40		.16		
McKenzie		2.00		2.300		1.57		1.69		
Beam		.40		.680		.50		.33		
Riverside Water Co., upper canal	27.50	24.54	24.54	37.40	32.36	20.58	27.00	34.02	26.08	21.
Gage canal, Santa Ana River		.64		.395		.29		.17		
Gage canal, Palm avenue weir	23.47		21.96		22.23		27.85		30.17	
Logsdon & Farrell		.54		1.26		.49		.20		
Whitlock		.09		.23		.00		.00		
Daley		.51		.72		1.12		.54		
McIntyre		.00		.14		.01		.00		
Whiting		.01		1.12		.13		.00		
Swamp		.69		.70		.89		.86		
Ranchero		.41		.24		.55	.80	.53	2.28	
Ward & Warren	1.56		1.60	.95	1.60	.10	.53		.30	1.
Mill flume of Riverside Water Co		2.56		2.67		2.17		.94		
Mill pump of Riverside Water Co	1.67			Not run.	1.88		1.52		1.20	
Camp Carlton ditch	1.02		2.55		2.60		1.67		1.70	
East Riverside district, or Riverside Highland Water Co	2.00		6.59		5.38		3.70			
Colton Terrace Water Co	1.30		1.69		1.54		1.53		1.08	
City of Colton pumping plant	3.89		4.94		3.21		3.54		3.53	
Bloomington flume	3.05		3.80		3.68		3.28		.00	
Meeks & Daley ditch		10.45		13.94		13.78		14.68		13.
West Riverside 350-inch pumping plant									5.94	
Rogers pumping plant									4.38	
Santa Ana River flume; Riverside pumping plant Nos. 1 and 2									5.03	
Total	65.46	44.68	67.67	63.79	74.48	42.93	71.42	54.18	81.69	

From the two preceding tables it will be noted that despite severe droughts which existed from 1898 to 1902, inclusive, the output of water from the gravel beds above Colton has but slightly diminished, the total being 144.69 second-feet in September, 1898, as compared with 120.21 second-feet in September, 1902. The amount of developed water in September, 1898, was 66.38 second-feet, and in September, 1902, 81.69 second-feet, while the natural return water between the same dates decreased from 78.31 second-feet to 38.52 second-feet. During this period much development work was done, and while these new supplies do not mean an absolute addition to the output from the district, the fact that the total supply was maintained notwithstanding the drought is a decided achievement.

SAN DIEMAS WASH.

See San Gabriel River, miscellaneous measurements, San Diemas Wash.

SAN FERNANDO CREEK.

Discharge measurement of San Fernando Creek, tributary of Los Angeles River, at San Fernando Mission, Los Angeles County.

Date.	Hydrographer.	Discharge.
1901.		*Sec.-feet.*
Jan. 28	J. B. Lippincott	3.21

SAN FRANCISQUITO CREEK.

Discharge measurement of San Francisquito Creek at junction with Santa Clara River, Los Angeles County.

Date.	Hydrographer.	Discharge.
1898.		*Sec.-feet.*
Aug. 11	F. H. Olmsted	2.07

SAN GABRIEL RIVER.

The drainage basin of this river lies on the southern slope of the Sierra Madre, the watershed being included in Los Angeles County, Cal. The various tributaries join the river before it enters its lowest canyon, whence it appears finally on the plain in the vicinity of Azusa. The seepage waters appear lower down in the valley. The floods discharge into the Pacific Ocean through a number of poorly defined storm channels. All the summer flow of this stream is now used for irrigation purposes in the vicinity of Azusa. Owing to the numerous diversions, it has been difficult to obtain accurate discharge measurements, but during 1898 the San Gabriel Electric Company completed its system, and measurements are now obtained with greater ease, and hence with greater accuracy. The head works of this company are located about 6 miles above the mouth of the canyon, the water is carried along the left side by a series of tunnels and

conduits, and a head of 400 feet is obtained where the electric power is generated. Weirs are placed on the conduit of the electric company, and the low water is measured at this point. The capacity of the conduit is 90 second-feet. The gaging station on the main river is located at the mouth of the canyon. The equipment consists of a rod, a cable, a car, and a tagged wire.

Discharge measurements of San Gabriel River at point near mouth of canyon near Azusa, Los Angeles County, Cal.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1895.		*Feet.*	*Sec.-feet.*	
Sept. 10	J. B. Lippincott	1.19	34.93	Total flow, meter measurement.
Nov. 5	do		13.25	Total flow.
Dec. 11	do		0.00	River.
Do	do		37.50	Canals.
Dec. 21	do	1.9	27.30	River.
Do	do		26.60	Canals.
	Total		53.90	
Dec. 21	J. B. Lippincott		27.05	River.
Do	do		26.60	Canals.
	Total		53.65	
1896.				
Feb. 17	J. B. Lippincott	1.35	4.86	River.
Do	do		33.00	Canals.
	Total		37.86	
Mar. 22	J. B. Lippincott	2.27	69.91	River.
Do	do		35.20	Canals.
	Total		105.11	
Apr. 30	J. B. Lippincott		0.00	River.
Do	do		55.20	Canals.
June 17	do		25.14	Irrigators upper weir.
Do	do		19.94	River.
Do	do		3.99	Azusa irrigation development.
Do	do		1.54	Vineland tunnel.
	Total		25.47	
July 22	John H. Quinton		0.00	River.
Do	do		26.75	Canals.
Nov. 22	J. B. Lippincott		0.00	
Do	do		21.10	Canals.

Discharge measurements of San Gabriel River, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1897.		*Feet.*	*Sec.-feet.*	
Jan. 10	J. B. Lippincott	1.28	4.50	River.
Do	do		19.93	Canals.
Do	do		1.65	Vineland canal water.
	Total		26.08	
Jan. 25	J. B. Lippincott	2.00	57.79	River.
Do	do		16.20	Canals.
Do	do		1.13	Vineland canal water.
	Total		75.12	
Feb. 1	J. B. Lippincott	5.1	1,725.0	River.
Do	do		00.0	Canals.
Feb. 2	do	3.4	422.1	River.
Do	do		00.0	Canals.
Mar. 12	do	3.3	410.1	River.
Do	do		18.0	Canals.
	Total		428.1	
Apr. 29	J. B. Lippincott	2.6	162.30	River.
Do	do		71.27	Canals.
	Total		233.57	
May 24	J. B. Lippincott	2.08	76.00	River.
Do	do		67.90	Canals.
	Total		143.90	
June 30	A. Q. Campbell		0.00	River.
Do	do		55.68	Canals.
July 5	do		0.00	River.
Do	do		53.94	Canals.
Aug. 7	do		0.00	River.
Do	do	2.33	31.37	Canals.
Sept. 1	do		0.00	River.
Do	do	2.2	24.25	Canals.
Sept. 29	do		0.00	River.
Do	do	2.1	19.28	Canals.
Nov. 13	do		7.56	River.
Do	do		24.16	Canals.
	Total		31.72	

Discharge measurements of San Gabriel River, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1897.		*Feet.*	*Sec.-feet.*	
Nov. 27	J. B. Lippincott		3.50	River.
Do	do		32.89	Canals.
	Total		36.39	
Nov. 28	J. B. Lippincott		42.11	At San Gabriel Power Company's intake; total flow.
1898.				
Jan. 12	do	1.36	23.29	River.
Do	do		25.00	Canals.
	Total		48.29	
Mar. 8	H. F. Crowe		12.3	Duarte canal.
Do	do		36.9	Azusa canal.
	Total river		49.2	
Apr. 2	J. B. Lippincott		11.30	Duarte canal.
Do	do		29.92	Azusa canal.
	Total river		41.22	
May 10	J. B. Lippincott		0	River.
Do	do		23.34	Canals.
May 17	do	1.03	15.40	River.
Do	do		44.61	Canals.
	Total		60.01	
July 1	F. H. Olmsted		3.59	Duarte canal.
Do	do		11.78	Azusa canal at Slaughter-house tunnel.
	Total river		15.37	
July 21	J. B. Lippincott		0	River.
Do	do		13.21	San Gabriel Power Company's canal headworks.
Aug. 16	do		0	Power Co.'s headworks; 3 p. m.
Do	do		6.20	Canals; 3 p. m.
Do	do		5.78	Canals; 4 p. m.
Do	do		5.60	Canals; 5 p. m.
Do	do		5.60	Canals; 6 p. m.
Do	do		5.78	Canals; 7 p. m.
Aug. 21	do		5.78	Canals; 8 p. m.

Discharge measurements of San Gabriel River, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1898.		*Feet.*	*Sec.-feet.*	
Aug. 22	J. B. Lippincott		0.00	River; 8 p. m.
Do	do		6.20	Canals; 8 p. m.
Aug. 23	do		0	River; 10 a. m
Do	do		8.48	Daily maximum; 10 a. m.
1899.				
Jan. 11	do	1.16	15.9	River.
Do	do		5.0	Waste.
Do	do		28.3	Canals.
	Total		49.2	
Jan. 16 to 19.	H. F. Parkinson		18.00	River and canals.
Aug. 26	do		5.5	Canals; no water in river.
1900.				
Nov. 21	S. G. Bennett		0	River; 11 a. m.
Do	do		20.15	Waste.
Do	do		26.13	Canal.
	Total		46.28	
1901.				
Jan. 7	S. G. Bennett	6.16	2,709.0	River (calculated).
Do	do		0	Canals.
Feb. 4	do	2.30	112.0	River.
Do	do		65.0	Canals.
	Total		177.0	
Feb. 5	S. G. Bennett	7.6	6,253.0	River (calculated).
Do	do		0	Canals.
Feb. 22	do	4.1	700.4	River.
Do	do		65.0	Canals.
	Total		765.4	
Mar. 5	S. G. Bennett	3.00	248.0	River.
Do	do		65.0	Canals.
	Total		313.0	

Discharge measurements of San Gabriel River, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1901.		*Feet.*	*Sec.-feet.*	
Mar. 29	S. G. Bennett	2.25	96.5	River.
Do	do		33.0	Canal.
	Total		129.5	
July 11	S. G. Bennett		0	River.
Do	do		31.6	Canal.
1902.				
Jan. 25	W. B. Clapp		0	River.
Do	do		50.94	Canals.
Feb. 26	J. B. Lippincott	2.05	126.19	River.
Do	do		64.00	Canal.
	Total		190.19	
Mar. 6	J. Ahern	1.57	46.2	River.
Do	do		62.0	Canals.
	Total		108.2	
Apr. 8	S. G. Bennett	1.4	26.0	River.
Do	do		44.6	Canals.
	Total		70.6	
June 12	S. G. Bennett		0	River.
Do	do		25.7	Canals.
Sept. 1	W. B. Clapp		5.0	Total flow.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
June 17, 1896	J. B. Lippincott	3.99	Azusa Irrigators Development Tunnel.
Aug. 24, 1898	do	.22	Same place; river being diverted through power company's conduit.
Do	do	.30	Irrigators Development Tunnel pumped; additional.

Discharge measurements of San Gabriel River, Azusa, Los Angeles County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
June 17, 1896	J. B. Lippincott	1.54	Mouth of Vineland tunnel.
Do	do	2.11	Same; pump running.
Apr. 29, 1897	do	2.23	Mouth of Vineland tunnel.
Do	do	2.11	Same; shaft No. 2.
Do	do	2.13	Same; at head of flume, between shafts Nos. 3 and 4.
Do	do	1.07	Same; right fork, above shaft No. 4.
May 24, 1897	do	1.88	Mouth of Vineland Tunnel.

Discharge measurements of San Gabriel River at intake of San Gabriel Power Company, Los Angeles County.

[Measurements by Edison Electric Company. The flow was unusually small in September, 1898, and these measurements were made to determine this minimum and its hourly fluctuation.]

Date.	Discharge.	Date.	Discharge.
September 15, 1898:	*Sec.-feet.*	September 15, 1898—Cont'd.	*Sec.-feet.*
7 a. m	8.16	6 p. m	6.94
7.30 a. m	8.28	6.30 p. m	6.94
8 a. m	8.40	12-hour mean	7.99
8.30 a. m	8.50		
9 a. m	8.72	September 15, 1898:	
9.30 a. m	8.84	7 p. m	6.94
10 a. m	8.84	7.30 p. m	6.94
10.30 a. m	8.84	8 p. m	6.94
11 a. m	8.84	8.30 p. m	6.94
11.30 a. m	8.72	9 p. m	7.04
12 m	8.62	9.30 p. m	7.04
12.30 p. m	8.40	10 p. m	7.04
1 p. m	8.28	10.30 p. m	7.04
1.30 p. m	8.06	11 p. m	7.04
2 p. m	7.84	11.30 p. m	7.04
2.30 p. m	7.62	12 midnight	7.04
3 p. m	7.50	September 16, 1898:	
3.30 p. m	7.40	12.30 a. m	7.04
4 p. m	7.18	1 a. m	7.04
4.30 p. m	7.04	1.30 a. m	7.18
5 p. m	6.94	2 a. m	7.18
5.30 p. m	6.94	2.30 a. m	7.28

Discharge measurements of San Gabriel River, etc.—Continued.

Date.	Discharge.
September 16, 1898—Cont'd.	*Sec.-feet.*
3 a. m	7.40
3.30 a. m	7.50
4 a. m	7.62
4.30 a. m	7.72
5 a. m	7.84
5.30 a. m	7.96
6 a. m	8.06
6.30 a. m	8.06
12-hour mean	7.29
September 16, 1898:	
7 a. m	8.28
7.30 a. m	8.40
8 a. m	8.28
8.30 a. m	8.50
9 a. m	8.72
9.30 a. m	8.94
10 a. m	9.06
10.30 a. m	9.06
11 a. m	8.94
11.30 a. m	8.84
12 m	8.72
12.30 p. m	8.50
1 p. m	8.28
1.30 p. m	8.06
2 p. m	7.84
2.30 p. m	7.62
3 p. m	7.50
3.30 p. m	7.40
4 p. m	7.18
4.30 p. m	7.04
5 p. m	6.94

Date	Discharge.
September 16. 1898—Cont'd.	Sec.-feet
5.30 p. m	6.8
6 p. m	6.8
6.30 p. m	6.8
12-hour mean	8.0
September 16, 1898:	
7 p. m	6.7
7.30 p. m	6.6
8 p. m	6.6
8.30 p. m	6.6
9 p. m	6.6
9.30 p. m	6.6
10 p. m	6.5
10.30 p. m	6.5
11 p. m	6.6
11.30 p. m	6.6
12 midnight	6.7
September 17, 1898:	
12.30 a. m	6.8
1 a. m	6.8
1.30 a. m	6.8
2 a. m	6.9
2.30 a. m	7.0
3 a. m	7.0
3.30 a. m	7.0
4 a. m	7.1
4.30 a. m	6.9
5 a. m	7.0
5.30 a. m	7.0
6 a. m	7.0
6.30 a. m	7.0
12-hour mean	6.9

The following table is prepared from measurements made three times daily for the San Gabriel Electric Company, and filed in a suit before the United States land office at Los Angeles, Cal. The mean of the three daily measurements is here given.

Estimated daily discharge, in second-feet, of San Gabriel River over weir on West Branch of North Fork, at Sycamore Flat, for 1900.

[Observer, San Gabriel Power Company.]

Day.	July.	August.	September.	October.
1	----------	0.23	0.19	0.20
2	0.28	.23	.19	.12
3	.27	.23	.17	.18
4	.27	.26	.22	.18
5	.26	.17	.12	.23
6	.28	.23	.12	.23
7	.24	.23	.22	.19
8	.23	.22	.18	.19
9	.25	.12	.20	.19
10	.23	.12	.22	.19
11	.25	.19	.22	.19
12	.25	.19	.22	.19
13	.22	.19	.22	.22
14	.27	.19	.18	----------
15	.27	.15	.18	----------
16	.31	.26	.12	----------
17	.31	.23	.12	----------
18	.27	.23	.25	----------
19	.31	.23	.15	----------
20	.39	.22	.12	----------
21	.39	.22	.15	----------
22	.24	.22	.12	----------
23	.26	.22	.15	----------
24	.26	.22	.22	----------
25	.28	.22	.27	----------
26	.37	.23	.26	----------
27	.37	.18	.26	----------
28	.26	.18	.22	----------
29	.23	.25	.20	----------
30	.23	.20	.17	----------
31	.23	----------	----------	----------
Total	.28	.21	.19	.19

Estimated daily discharge, in second-feet, of San Gabriel River over weir on North Branch of North Fork, at Sycamore Flat, for 1900.

[Observer, San Gabriel Power Company.]

Day.	July.	August.	September.	Octo
1		0.89	0.62	0.6
2	0.92	.89	.62	.6
3	.92	.89	.62	.6
4	.92	.95	.62	.6
5	.89	.95	.60	.6
6	.89	.74	.65	.6
7	.89	.74	.61	.5
8	.82	.74	.61	.5
9	.80	.77	.83	.5
10	.70	.77	.61	.5
11	.81	.74	.61	.5
12	.83	.74	.63	.5
13	.86	.77	.61	.5
14	.95	.68	.63	
15	.97	.74	.63	
16	.97	.62	.59	
17	.97	.65	.59	
18	.97	.65	.59	
19	.97	.62	.59	
20	.97	.60	.59	
21	.97	.60	.53	
22	.96		.53	
23	1.07	.55	.53	
24	.95	.52	.81	
25	.95	.52	.68	
26	.96	.56	.65	
27	.68	.57	.65	
28	.68	.57	.68	
29	.89	.57	.68	
30	.86	.74	.68	
31	.68			
Total	.89	.70	.63	.6

Estimated daily discharge, in second-feet, of San Gabriel River over weir on West Fork above mouth of North Fork for 1900.

[Observer, San Gabriel Power Company.]

Day.	July.	August.	September.	October.
1	0.55	0.05	0.12	0.16
2	.62	.02	.12	.16
3	.68	.....	.12	.16
4	.62	.....	.12	.16
5	.53	.....	.08	.15
6	.55	.....	.11	.20
7	.55	.....	.16	.20
8	.55	.....	.12	.16
9	.44	.....	.12	.16
10	.34	.....	.16	.13
11	.29	.....	.16	.20
12	.26	.08	.12	.20
13	.24	.07	.12	.20
14	.20	.08	.16	.....
15	.13	.08	.16	.....
16	.12	.12	.16	.....
17	.16	.10	.16	.....
18	.16	.12	.11	.....
19	.12	.10	.12	.....
20	.12	.12	.12	.....
21	.07	.12	.16	.....
22	.12	.10	.16	.....
23	.....	.07	.....	.....
24	.....	.08	.....	.....
25	.08	.08	.12	.....
26	.....	.....	.20	.....
27	.....	.08	.16	.....
28	.05	.08	.16	.....
29	.08	.10	.13	.....
30	.05	.12	.14	.....
31	.05	.10	.....	.....
Total	.29	.09	.14	.17

Estimated daily discharge, in second-feet, of San Gabriel River over weir on Cold water Creek, 2¼ miles above mouth, for 1900.

[Observer, San Gabriel Power Company.]

Day.	July.	August.	September.	October
1		0.43	0.52	
2			.58	0.6
3		.49	.62	.6
4		.46	.57	.6
5		.54	.55	.6
6		.53	.56	.61
7		.50	.51	.5
8		.50	.51	.5
9		.53	.56	.5
10		.53	.50	.5
11		.53	.55	.6
12		.51	.52	.6
13		.46		.6
14		.47		
15		.45		
16		.45		
17		.47		
18		.47		
19		.52		
20		.55		
21		.56		
22		.51		
23		.49		
24		.45		
25		.44		
26		.45		
27	0.37	.42		
28	.49	.42		
29	.50	.41		
30	.47	.40		
31	.46	.56		
Total	.46	.48	.55	.6

Estimated daily discharge, in second-feet, of San Gabriel River over weir 100 yards above Fish Fork, for 1900.

[Observer, San Gabriel Power Company.]

Day.	July.	August.	September.	October.
1	2.24			1.67
2	2.48			1.67
3	2.48	1.72		1.71
4	2.42	1.80		1.84
5	2.33	1.80		1.84
6	2.27	1.80		1.80
7	2.06	1.80		1.72
8	2.12	1.80		1.67
9	2.09	1.80	1.84	1.71
0	2.15	1.80	1.80	1.71
1	2.09	1.80	1.72	1.75
2	2.15	1.97	1.76	1.76
3	2.15	1.92	1.72	1.89
4	2.03	1.85	1.76	
5	2.03	1.80	1.76	
6	2.12	1.68	1.80	
7	2.00	1.76	1.71	
8	2.00	1.68	1.72	
9	1.97	1.68	1.72	
0	1.97	1.64	1.68	
1	2.00	1.68	1.59	
2	2.00	1.68	1.63	
3	2.00	1.68	1.79	
4	1.97	1.68	1.89	
5	2.18	1.76	1.84	
6	2.00	1.68	1.84	
7	2.00	1.60	1.67	
8	1.95	1.60	1.63	
9	1.77	1.68	1.67	
0	1.77	1.68	1.79	
1		1.97		
Total	2.09	1.75	1.74	1.75

Estimated daily discharge, in second-feet, of San Gabriel River over weir on Fish Fork, 100 yards from mouth, for 1900.

[Observer, San Gabriel Power Company.]

Day.	July.	August.	September.	October.
1	1.42			0.95
2	1.66			.96
3	1.68	0.99		.95
4	1.66	.96		.96
5	1.28	1.02		.95
6	1.25	1.06		.95
7	1.16	1.06		.93
8	1.18	.92		.93
9	1.08	.95	1.52	.95
10	.98	1.02	.92	.90
11	.96	.99	.96	.95
12	.98	1.11	1.13	.95
13	.98	1.11	1.10	1.01
14	1.04	1.02	.99	
15	1.02	.99	1.08	
16	1.25	.90	.94	
17	.93	.90	.93	
18	1.00	.84	.89	
19	1.00	.84	.86	
20	1.00	.95	.84	
21	1.12	.89	.84	
22	1.12	.90	.80	
23	1.13	.90	.98	
24	1.06	.90	1.02	
25	1.02	.92	1.01	
26	.90	.92	.98	
27	.90	.92	.78	
28	.90	.92	.80	
29	.87	.99	.81	
30	.87	.95	.84	
31		1.08		
Total	1.11	.96	.96	.94

Estimated daily discharge, in second-feet, of San Gabriel River over weir on Iron Fork, 100 yards from mouth, for 1900.

[Observer, San Gabriel Power Company.]

Day.	July.	August.	September.	October.
1	1.97			1.05
2	1.97	0.87		1.08
3	2.08	1.05		1.05
4	2.09	1.09		1.12
5	1.89	1.16		1.20
6	1.91	1.16		1.12
7	1.88	.62		1.09
8	1.66	1.16		1.16
9	1.55	1.12	1.09	1.12
10	1.58	1.16	1.12	1.09
11	1.50	1.24	1.12	1.20
12	1.39	1.06	1.09	1.20
13	1.42	1.09	1.09	1.23
14	1.42	1.20	1.12	1.31
15	1.44	1.24	1.16	
16	1.42	1.12	1.09	
17	1.42	1.12	1.16	
18	1.37	1.09	1.09	
19	1.37	1.09	1.09	
20	1.42	1.16	1.05	
21	1.31	1.12	.91	
22	1.34	1.12	.87	
23	1.37	1.02	1.12	
24	1.24	1.02	1.27	
25	1.29	.95	1.20	
26	1.24	.95	1.20	
27	1.26	.95	1.05	
28	1.21	1.02	1.01	
29	1.09	1.09	1.01	
30	1.14	1.09	1.16	
31	1.24	1.12		
Total	1.50	1.07	1.09	1.14

Discharge measurements of San Gabriel River at point above Iron Fork.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
November, 1896	F. C. Finkle	7.7
December, 1896	do	7.4
January, 1897	do	28.4
February, 1897	do	42.0
March, 1897	do	52.1
April, 1897	do	27.9
May, 1897	do	24.7
June, 1897	do	25.4
July, 1897	do	17.[illegible]
August, 1897	do	16.4
September, 1897	do	16.[illegible]
April, 1900	J. B. Lippincott et al	5.7[illegible]

Discharge measurements of Iron Fork of San Gabriel River at mouth.

Date.	Hydrographer.	Discharge
		Sec.-feet
November, 1896	F. C. Finkle	3.6
December, 1896	do	3.0
January, 1897	do	10.1
February, 1897	do	19.3
March, 1897	do	18.9
April, 1897	do	10.2
May, 1897	do	8.9
June, 1897	do	7.7
July, 1897	do	8.6
August, 1897	do	3.9
September, 1897	do	4.1
April, 1900	J. B. Lippincott et al	1.9[illegible]

Discharge measurements of North Fork of San Gabriel River.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
November, 1896	F. C. Finkle	3.7
December, 1896	do	3.6
January, 1897	do	10.8
February, 1897	do	17.0
March, 1897	do	19.4
April, 1897	do	13.8
May, 1897	do	11.2
June, 1897	do	7.1
July, 1897	do	5.9
August, 1897	do	4.1
September, 1897	do	3.9
April, 1900	J. B. Lippincott et al	1.43

Discharge measurements of Coldwater Creek, San Gabriel River, Los Angeles County, Cal.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
November, 1896	F. C. Finkle	4.1
December, 1896	do	4.2
January, 1897	do	11.3
February, 1897	do	19.1
March, 1897	do	17.8
April, 1897	do	11.3
May, 1897	do	9.8
June, 1897	do	8.3
July, 1897	do	6.5
August, 1897	do	5.1
September, 1897	do	5.0
April, 1900	J. B. Lippincott et al	1.46

Discharge measurements of Bear Creek, San Gabriel River, Los Angeles County, Cal.

Date.	Hydrographer.	Discharge.
		Sec.-feet
November, 1896	F. C. Fincle	3.6
December, 1896	do	3.4
January, 1897	do	9.1
February, 1897	do	24.7
March, 1897	do	23.9
April, 1897	do	17.3
May, 1897	do	14.1

Discharge measurements of Bear Creek, San Gabriel River, at point near mouth, Los Angeles County, Cal.

Date	Hydrographer.	Discharge.
		Sec.-feet
June, 1897	F. C. Fincle	6.3
July, 1897	do	6.2
August, 1897	do	4.4
September, 1897	do	4.5
April, 1900	J. B. Lippincott et al	2.4

Discharge measurement of West Fork of San Gabriel River above Bear Creek, Los Angeles County, Cal.

Date.	Hydrographer.	Discharge.
		Sec.-feet
April, 1900	J. B. Lippincott et al	1.9

Discharge measurement of West Fork of San Gabriel above junction with East Fork, or Main River, Los Angeles County, Cal.

Date.	Hydrographer.	Discharge.
		Sec.-feet
August 23, 1898	J. B. Lippincott	2.[illegible]

Discharge measurement of East Fork of San Gabriel above junction with West Fork, Los Angeles County, Cal.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
August 23, 1898	J. B. Lippincott	7.11

Discharge measurement of San Gabriel River at junction of East and West forks.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
August 23, 1898	J. B. Lippincott	9.78
Do	do	[a] 8.42
Loss		1.36

[a] San Gabriel River at headworks of San Gabriel Power Company.

Discharge measurement of Cattle Canyon above Coldwater, San Gabriel River, Los Angeles County, Cal.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
April, 1900	J. B. Lippincott et al	0.32

Discharge measurements of San Gabriel River at various points in watershed below El Monte Narrows.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
July 3, 1898	F. H. Olmsted	2.52	Whittier ditch, El Monte road crossing.
Do	do	9.06	Temple ditch, left of Narrows flume.
Do	do	8.79	Baldwin ranch house road.
Do	do	6.18	Original river channel.
Do	do	3.36	Campers station.
Do	do	1.22	Puente ditch: 50 per cent of usual head in ditch.
Do	do	29.79	Old mission bridge (Rio Hondo).
	Total	60.92	

Discharge measurements of San Gabriel River at various points in watershed.

Date.	Hydrographer.	Locality.	Area of section.	Mean velocity.	Discharge.
1897.			*Sq. feet.*	*Ft. per sec.*	*Sec.-feet.*
Dec. 5	J. B. Lippincott	San Gabriel River, Los Angeles and Whittier road bridge.	.....	.....	106
1900.					
Aug. 7	S. G. Bennett	East Whittier ditch at El Monte road crossing.	4.08	1.4	5.71
Aug. 7	do	Killion's pumping plant, 4 wells near El Monte.	5.76	1.774	10.22
Aug. 7	do	Cameron or Sheep Creek ditch.	9.62	.25	2.46
Aug. 7	do	Rincon ditch	1.99	1.24	2.47
Aug. 7	do	Old Temple ditch	1.22	.98	1.20
Aug. 7	do	Cate ditch, near head	9.47	.92	8.71
Aug. 7	do	Standifer ditch	9.34	1.557	14.56
Aug. 7	do	Banta ditch	11.45	1.349	15.44
		Total, San Gabriel River at intake of Standifer and Banta ditches.	.....	.....	30.00
Aug. 8	do	Rodriguez ditch, near Old Mission.	1.20	1.67	2.00
Aug. 8	do	Rio Honda or Old San Gabriel, under Mission bridge.	31.42	.74	23.2
Aug. 8	do	Arroyo ditch	11.90	1.83	21.8
Aug. 8	do	Little Lake	.60	.37	.22
Aug. 8	.....	[a] Agricultural ditch	.....	.....	Dry
Sept. 17	W. W. Cockins	Bradbury ranch, Santa Anita, and Rose avenues.	.....	.....	1.44
Sept. 17	do	San Gabriel Sanitarium tunnel.	.....	.....	.04
Sept. 18	do	W. A. Highland, Rose avenue, Lamanda Park.	.....	.....	.10
Sept. 19	do	Chapman ranch, 2 wells pumped; 1 artesian well.	.....	.....	1.0
Sept. 19	do	Chapman ranch, 4 wells pumped.	.....	.....	1.9
Sept. 20	do	Chapman ranch, natural flow of ciénaga.	.....	.....	.0
Sept. 20	do	Chapman ranch dairy	.52	1.38	.7
		Chapman ranch, total	.....	.....	3.7

[a] San Gabriel River dry below this point.

Discharge measurements of San Gabriel River, etc.—Continued.

Date.	Hydrographer.	Locality.	Area of section.	Mean velocity.	Discharge.
1900.			*Sq. feet.*	*Ft. per sec.*	*Sec.-feet.*
Sept. 20	W. W. Cockins	Alhambra Water Co., weir No. 1.			2.58
Sept. 20	do	Alhambra Water Co., weir No. 2.			.34
		Total			2.92
Sept. 24	do	Santa Anita Canyon, natural flow.			.22
Sept. 24	do	Sierra Madre Water Co. (weir).			.145
Sept. 24	do	Remamettes east of Sierra Madre.	0.12	0.75	.09
Sept. 18	do	Monrovia Water Co., 3 wells pumped.			3.24
Sept. 24	do	Monrovia Canyon, to Monrovia Water Co. (weirs).			.428
		To Bradbury			.116
		Total			.544
Sept. 21	do	Duarte Mutual Improvement and Canal Co.			.78
Sept. 21	do	Beardsley Water Co			.44
Sept. 13	do	Morengo Water Co. Southern Pacific Co.'s Garfield station (weir).			1.82
Sept. 13	do	Morengo Water Co.'s weir in Morengo Canyon (weir).			.46
Sept. 13	do	Los Robles Water Co.'s reservoir (weir).			.31
Sept. 13	do	Reservoir at junction of Glenarm and Los Robles avenues, Pasadena (weir).			.068
Sept. 13	do	Graves & Bean tunnel	2.06	5.34	1.10
Sept. 14	do	Brick kiln between Molino and Hope streets, Pasadena.			.02
Sept. 14	do	Oak Knoll Park, Pasadena.	.096	3.53	.34
Sept. 14	do	Patton tunnel, near Kewen Lake.	.047	3.80	.18
Sept. 14	do	Patton's east canyon	.87	1.70	1.48
Sept. 17	do	Patton's east canyon, natural flow; pump not running.	.36	1.03	.37

Discharge measurements of San Gabriel River, etc.—Continued.

Date.	Hydrographer.	Locality.	Area of section.	Mean velocity.	Dis charge
1900.			*Sq. feet.*	*Ft. per sec.*	*Sec.-ft.*
Sept. 17	W. W. Cockins	Mission ditch, Patton ranch.			0.3
Sept. 14	do	Winston ranch	0.60	0.93	.5
Sept. 14	do	Shorbes ranch (weir)			.1
Sept. 15	do	Yoakham's ranch (weir).			.1
Sept. 15	do	Robert Liddel, San Pasqual and Shorb (weir).			.1
Sept. 15	do	R. W. Scoville (weir)			.0
Sept. 15	do	Mrs. Black, San Pasqual and Craig streets (weir).			.0
Sept. 15	do	Morningside ranch (weir).			.0
Sept. 27	do	Glendora, Azusa Irrigation Co.:			
		Massey well			1.5
		Paine well			.9
		Total			2.4
Sept. 27	Irwin F. Daniels	Wells in San Diemas wash:			
Sept. 27	do	Daty & Sons			1.9
Sept. 27	do	San Diemas Irrigation Co., F. D. Smith well			1.3
Sept. 27	do	Thacker well			.8
Sept. 27	do	Smith well (private).			.3
Sept. 27	do	Chapman well			.7
Sept. 27	do	Ruddock well			.5
Sept. 27	do	Artesian Belt Co., 2 wells.			1.6
Sept. 27	do	Azusa city well			.7
Sept. 27	do	Walker's well			.3
Sept. 27	do	Citizens' Water Co. (Covina).			.1
Sept. 27	do	Covina plant, Deacon well.			.4
Sept. 27	do	Natural flow, San Diemas Canyon.			.8
Sept. 27	do	Spark's well			.4
		Total			11.5

Discharge measurements of San Gabriel River at wells on Lordsburg Mesa.

Date.	Hydrographer.	Locality.	Area of section.	Mean velocity.	Discharge.
			Sq. feet.	*Ft. pr. sec.*	*Sec.-feet.*
Sept. 27	Irwin F. Daniels	Richards, 4 wells			1.52
Sept. 27	do	Sumner			.48
Sept. 27	do	Sheldon Bros			.30
Sept. 27	do	La Verne Land and Water Co.			.70
Sept. 27	do	Rodgers			.10
Sept. 27	do	True (5 days in 30)			.16
Sept. 27	do	Rodney Soper			.24
Sept. 27	do	Hayes & Stratton			.20
Sept. 27	do	Wallace			.16
Sept. 27	do	Mullard			.30
Sept. 27	do	Douglas & McQuilly			.76
Sept. 27	do	Norris			.30
Sept. 27	do	Williams Bros			.80
Sept. 27	do	Kulp (intermittent), south of Mesa avenue.			.20
Sept. 27	do	D. Fulton			.50
Sept. 27	do	Steves			.20
Sept. 27	do	Daniels & Overholtzer			1.34
Sept. 27	do	Massey, 2 wells			.54
Sept. 27	do	Hauser Bros			.76
Sept. 27	do	Moorwaw & Son			.50
Sept. 27	do	Sleider			.88
Sept. 27	do	Rutherford & Co			.40
Sept. 27	do	New Deal Water Co			.40
Sept. 27	do	Kiser			.90
		Total			12.64

Estimated monthly discharge of San Gabriel River at Azusa, Los Angeles County

[Drainage area, 222 square miles.]

Month.	Discharge.			Run-off.		
	Maximum.	Minimum.	Mean.	Total discharge.	Per square mile.	Depth
1894.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
May	50	27	32	1,968	0.14	0.16
June	27	17	23	1,369	.10	.11
July	17	9	12	738	.05	.06
August	27	10	14	861	.06	.07
September	23	13	15	893	.07	.08
October	16	13	14	861	.06	.07
November 1 to 15	14	13	13	387	.06	.06
1895.						
August 8 to 31	47	38	42	1,999	.19	.17
September	39	29	32	1,904	.14	.16
October	32	27	29	1,783	.13	.15
November	50	29	40	2,380	.18	.20
December	45	37	42	2,582	.19	.22
1896.						
January	25	0	11	676	0.05	0.06
February	28	3	12	690	.05	.06
March	134	27	75	4,612	.34	.39
April	46	0	11	655	.05	.06
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	177	0	12	738	.05	.06
November	16	0	3	179	.01	.01
December	12	0	2	123	.01	.01
The year	177	0	11	7,673	.05	.67

NOTE.—During the summer months all this water is diverted by the canals. For 1894 and 1896 the above table is for the total discharge from the drainage basin. Subsequent to 1895 the table shows the separate flow in river and canals, except where combined and so stated.

Estimated monthly discharge of San Gabriel River at Azusa, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1897.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	130	5	40	2,484	0.181	0.201
February	1,710	46	332	18,420	1.494	1.555
March	1,765	275	448	27,572	2.020	2.329
April	345	141	259	15,417	1.166	1.301
May	141	28	82	5,042	.369	.420
June	28	.2	5	274	.021	.024
July	0	0	0	0	0	.000
August	0	0	0	0	0	.000
September	0	0	0	0	0	.000
October	1,600	0	72	4,458	.322	.372
November	15	.4	8	475	.036	.040
December	5	3.0	4	221	.016	.018
The year	1,765	0	104	74,302	.469	6.260
1898.						
January	31	0	14	863	0.06	0.07
February	41	0	11	622	.05	.05
March	1	0	0.03	2	0	0
April	0	0	0	0	0	0
May	63	0	4.5	277	.02	.02
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
The year	63	0	2.5	1,764	.01	.14

Estimated monthly discharge of San Gabriel River at Azusa, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1899.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
January	16	0	1.2	74	0.005	0.006
February	0	0	0	0	0	0
March	0	0	0	0	0	0
April	0	0	0	0	0	0
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	13	0	.42	26	0.002	.002
November	0	0	0	0	0	0
December	0	0	0	0	0	0
The year	16	0	.13	100	.007	.007
1900.						
January	49	0	2	123	0.01	0.01
February	0	0	0	0	0	0
March	0	0	0	0	0	0
April	0	0	0	0	0	0
May	38	0	2	123	.01	.01
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	0	0	0	0	0	0
November	5,168	0	172	10,235	0.77	0.85
December	0	0	0	0	0	0
The year	5,168	0	15	10,481	.07	.97

Estimated monthly discharge of San Gabriel River at Azusa, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
anuary	1,450	0	111	6,825	0.50	0.58
'ebruary	2,600	70	613	34,044	2.76	2.87
larch	370	80	158	9,715	.71	.82
pril	75	13	43	2,559	.19	.21
lay	200	18	55	3,382	.25	.29
une	27	0	7	417	.03	.03
uly	0	0	0	0	0	0
ugust	0	0	0	0	0	0
eptember	0	0	0	0	0	0
)ctober	70	0	3	184	.01	.01
Jovember	0	0	0	0	0	0
)ecember	0	0	0	0	0	0
The year	2,600	0	83	57,126	.37	4.81
1902.						
anuary	0	0	0	0		
'ebruary	57	0	3	167		
larch	318	4	38	2,337		
pril	37	0	7	417		
lay	0	0	0	0		
une	0	0	0	0		
uly	0	0	0	0		
ugust	0	0	0	0		
eptember	0	0	0	0		
)ctober	0	0	0	0		
Jovember	0	0	0	0		
)ecember	0	0	0	0		
The year	318	0	4	2,921		

Estimated monthly discharge of San Gabriel canals at Azusa, Los Angeles County.

[Drainage area, 222 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1896.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	26	26	26	1,599	0.12	0.14
February	34	26	30	1,726	.14	.15
March	43	35	36	2,214	.16	.18
April	45	40	43	2,559	.19	.2[illegible]
May	42	29	36	2,214	.16	.1[illegible]
June	27	13	19	1,131	.09	.1[illegible]
July	15	9	12	738	.05	.0[illegible]
August	36	9	14	861	.06	.0[illegible]
September	19	11	13	774	.06	.0[illegible]
October	17	10	11	676	.05	.0[illegible]
November	24	15	17	1,012	.08	.0[illegible]
December	25	18	20	1,230	.09	.1[illegible]
The year	45	9	23	16,734	.10	1.4[illegible]
1897.						
January	22	13	17.56	1,072	0.079	0.0[illegible]
February	20	3	13.10	726	.059	.0[illegible]
March	21	0	17.14	1,051	.077	.0[illegible]
April	60	15	35.30	2,102	.159	.17
May	68	55	62.97	3,810	.284	.3[illegible]
June	71	54	63.20	3,759	.285	.3[illegible]
July	52	27	38.13	2,343	.171	.1[illegible]
August	34	22	26.45	1,613	.118	.1[illegible]
September	23	18	20.66	1,226	.088	.0[illegible]
October	26	10	18.03	1,106	.081	.0[illegible]
November	29	16	23.30	1,385	.105	.1[illegible]
December	29	25	26.84	1,648	.121	.1[illegible]
The year	71	0	30.20	21,831	.136	1.8[illegible]

Estimated monthly discharge of San Gabriel canals at Azusa, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1898.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	32	23	26	1,591	0.12	0.14
February	34	10	29	1,618	.13	.14
March	48	28	35	2,129	.16	.18
April	37	25.3	33	1,950	.15	.17
May	45	20.0	32	1,947	.14	.16
June	30	14.5	19	1,159	.09	.10
July	14	9.0	11	672	.05	.06
August	9	5.0	7	456	.03	.03
September	10	6.1	8	467	.04	.04
October	10	7.5	9	533	.04	.04
November	11	8.0	10	580	.04	.04
December	18	11.7	14	832	.06	.07
The year	48	5.0	19.4	13,934	.09	1.17
1899.						
January	33	15	21.8	1,340	0.098	0.115
February	27	20	22.0	1,244	.102	.106
March	40	18	26.0	1,623	.119	.137
April	28	16	21.0	1,262	.096	.107
May	17	12	14.0	842	.062	.071
June	22	5	10.0	565	.043	.048
July	4	3	4.0	221	.016	.018
August	6	4	5.0	295	.022	.025
September	6	3	4.0	220	.019	.021
October	26	4	11.1	683	.050	.058
November	24	10	14.0	847	.064	.071
December	39	16	20.0	1,247	.091	.105
The year	40	3	14.4	10,389	.065	.882

Estimated monthly discharge of San Gabriel canals at Azusa, etc.—Continued.

Month.	Discharge.				Run-off	
	Maximum.	Minimum.	Mean.	Total discharge.	Per square mile.	Depth
1900.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
January	50	22	30	1,845	0.14	0.1
February	23	18	20	1,111	.09	
March	30	16	20	1,230	.09	
April	26	13	17	1,012	.08	
May	56	16	35	2,152	.16	
June	22	8	15	893	.07	
July	10	4	6	369	.03	
August	5	4	4	246	.02	
September	6	3	4	238	.02	
October	6	4	5	307	.02	
November	55	5	14	833	.06	
December 1 to 16	53	31	40	1,269	.18	
The year	55	3	18	11,505	.08	
1901.						
January	90	0	58	3,566	0.26	
February	70	5	67	3,721	.30	
March	70	35	63	3,874	.28	
April	84	55	67	3,987	.30	
May	72	59	66	4,058	.30	
June	66	41	56	3,332	.25	
July	41	24	30	1,845	.14	
August	27	15	20	1,230	.09	
September	20	15	17	1,012	.08	
October	64	0	21	1,291	.09	
November	50	29	32	1,904	.14	
December	30	26	27	1,660	.12	
The year	90	0	44	31,480	.20	

Estimated monthly discharge of San Gabriel canals at Azusa, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1902.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	51	24	28	1,722		
February	63	27	34	1,888		
March	62	55	61	3,750		
April	62	46	59	3,510		
May	48	30	39	2,398		
June	29.5	13.5	20	1,190		
July	17	7.5	11	676		
August	8.5	6	7	430		
September	6	4.5	5	298		
October	10.5	5.5	7	430		
November	62	7.5	19	1,131		
December	68	16	32	1,968		
The year	68	4.5	27	19,391		

Estimated monthly discharge of San Gabriel River and canals at Azusa, Los Angeles County.

[Drainage area, 222 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1896.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	51	26	37	2,275	0.17	0.20
February	61	36	41	2,358	.18	.19
March	169	37	111	6,825	.50	.58
April	91	40	54	3,213	.24	.27
May	40	29	36	2,214	.16	.18
June	27	13	19	1,131	.09	.10
July	15	9	12	738	.05	.06
August	36	9	14	861	.06	.07
September	19	11	13	774	.06	.07
October	188	10	24	1,476	.11	.13
November	40	15	19	1,131	.09	.10
December	37	17	22	1,353	.10	.12
The year	188	9	34	24,349	.15	2.07

Estimated monthly discharge of San Gabriel River and canals at Azusa, Los Angeles County—Continued.

Month.	Discharge.				Run-off.	
	Maximum.	Minimum.	Mean.	Total discharge.	Per square mile.	Depth
1897.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	147	25	57.9	3,617	0.260	0.30
February	1,713	64	344.8	19,146	1.553	1.73
March	1,765	294	465.6	28,623	2.097	2.41
April	370	201	294.4	17,519	1.325	1.48
May	196	94	145.0	8,851	.653	.75
June	91	54	67.8	4,033	.306	.34
July	52	27	38.1	2,343	.171	.19
August	34	23	26.4	1,613	.118	.13
September	23	18	20.7	1,226	.088	.10
October	1,640	22	90.5	5,564	.403	.46
November	34	31	33.3	1,860	.141	.16
December	34	28	30.5	1,875	.137	.15
The year	1,765	18	134.6	96,270	.604	8.07
1898.						
January	63	28	40	2,453	0.18	0.2
February	70	32	40	2,241	.18	.19
March	48	28	35	2,131	.16	.18
April	37	25.3	33	1,950	.15	.17
May	83	25.0	36	2,223	.16	.18
June	30	14.5	19	1,159	.09	.10
July	14	9.0	11	672	.05	.06
August	9	5.0	7	456	.03	.04
September	10	6.1	8	467	.04	.04
October	10	7.5	9	533	.04	.05
November	11	8.0	10	580	.04	.05
December	18	11.7	14	832	.06	.07
The year	83	5.0	22	15,697	.10	1.34

Estimated monthly discharge of San Gabriel River and canals at Azusa, Los Angeles County—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1899.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	33	15	23	1,414	0.104	0.120
February	28	20	22	1,244	.102	.106
March	40	18	26	1,623	.119	.137
April	28	16	21	1,262	.096	.107
May	17	12	14	842	.062	.071
June	22	5	10	565	.043	.048
July	4	3	4	221	.016	.018
August	6	4	5	295	.022	.025
September	6	3	4	220	.019	.021
October	26	4	11	709	.050	.058
November	24	10	14	847	.064	.071
December	39	16	20	1,247	.091	.105
The year	40	3	5	10,489	.065	.887
1900.						
January	89	22	32	1,968	0.14	0.16
February	23	18	20	1,111	.09	.09
March	30	16	20	1,230	.09	.10
April	26	13	17	1,012	.08	.09
May	86	16	37	2,275	.17	.20
June	22	8	15	893	.07	.08
July	10	4	6	369	.03	.03
August	5	4	4	246	.02	.02
September	6	3	4	238	.02	.02
October	6	4	5	307	.02	.02
November	5,200	5	186	11,068	.84	.93
December 1 to 16	53	31	40	1,269	.18	.11
The year	5,200	3	32	21,986	.15	1.85

Estimated monthly discharge of San Gabriel River and canals at Azusa, Los Angeles County—Continued.

Month.	Discharge.			Total discharge.	Run-off	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
January	1,450	28	169	10,391	0.76	0.87
February	2,605	137	680	37,765	3.06	3.53
March	440	135	221	13,589	1.00	1.15
April	130	95	110	6,545	.50	.56
May	272	83	121	7,440	.55	.63
June	93	41	63	3,749	.28	.31
July	41	24	30	1,845	.14	.16
August	27	15	20	1,230	.09	.10
September	20	15	17	1,012	.08	.09
October	122	15	24	1,476	.11	.13
November	50	29	32	1,904	.14	.16
December	30	26	27	1,660	.12	.14
The year	2,605	15	126	88,606	.57	7.79
1902.						
January	51	24	28	1,722	0.13	0.15
February	120	38	37	2,055	.17	.17
March	378	63	99	6,087	.45	.52
April	99	48	66	3,927	.30	.33
May	48	30	39	2,398	.17	.20
June	29.5	13.5	20	1,190	.09	.10
July	17	7.5	11	676	.05	.06
August	8.5	6	7	430	.03	.04
September	6	4.5	5	298	.02	.02
October	10.5	5.5	7	430	.03	.03
November	80	7.5	19	1,131	.09	.10
December	68	16	32	1,968	.14	.16
The year	378	4.5	31	22,312	.14	1.87

SAN GREGORIO CREEK.

Discharge measurement of San Gregorio Creek, San Mateo County.

Date.	Hydrographer.	Discharge.	Locality.
1893.		*Sec. ft.*	
ct. 17	W. W. Brier	6.49	One-third mile above San Gregorio.

SAN JOAQUIN RIVER.

The headwater tributaries of this river receive the drainage from ıe crests of the Sierra Nevada north of Mount Whitney. The fall the river is rapid, with many favorable locations for power devel- ɔment, and in one case advantage has been taken of the fall on the orth Fork, and a power plant constructed, developing electric power ır transmission to Fresno and Hanford, Cal. During 1899 a second orage reservoir was under course of construction on the North ɔrk, which will tend further to regulate the flow of the river. No ɜrmanent diversions above the gaging station are made, but the ater is extensively used below for irrigation purposes. The gage rod the station was established by the Southern Pacific Railway Company 1879. The old trestle bridge was torn down by the railroad company ıring 1899 and a new iron structure was erected in its place. This ɔcessitated a new gage rod, which was set to the datum of the old ıge and bolted to the western side of the central concrete pier. The ɜnch mark is a nail in a post at the south end of the bridge on the ɛst side, 0.2 foot above the ground and marked "B. M." It is at ı elevation of 24.12 feet above gage datum. The channel for some stance above and below the bridge is straight, and the water has a ıiform velocity. The right bank is high, rocky, and steep. The ɜd of the stream is of sand and gravel.

ɜscharge measurements of San Joaquin River at Herndon, Fresno County, Cal.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-feet.*
ın. 9	A. P. Davis and J. B. Lippincott	4	1,995
ar. 22	J. B. Lippincott	3.85	1,938
ay 5	do	6.65	7,419
ıne 23	do	8.00	11,225
ıg. 31	do	3.00	677
ɛt. 11	do	2.6	332
ɔv. 25	do	2.55	270
1896.			
pr. 13	J. A. Vogleson	4.1	2,406
ıne 11	J. B. Lippincott	9.33	15,942
ɔv. 2	do	2.75	424

Discharge measurements of San Joaquin River at Herndon, etc.—Continued.

Date.	Hydrographer	Gage height.	Dis-charge
1897.		*Feet.*	*Sec-feet*
Feb. 14	J. B. Lippincott	3.58	1,1
May 31	do	8.60	10,3
July 16	A. Q. Campbell	4.5	3,2
Sept. 8	do	2.66	3
Nov. 2	do	2.92	7
Dec. 21	J. B. Lippincott	3.00	6
1898.			
Apr. 19	J. B. Lippincott	5.42	4,1
May 30	do	4.58	2,2
July 28	do	3	6
Sept. 2	do	2.52	3
Dec. 20	do	2.5	3
1899.			
Mar. 5	J. B. Lippincott	3.25	7
Apr. 18	S. G. Bennett	6.34	5,4
May 13	do	a7	7,4
June 2	do	5.76	4,1
June 27	do	4.90	2,9
Aug. 1	do	3.32	7
Sept. 8	do	2.67	3
1900.			
Feb. 2	J. B. Lippincott	3.25	1,0
Apr. 3	S. G. Bennett	4.66	2,6
May 15	do	5.91	4,4
June 18	do	5.67	3,7
Aug. 9	do	2.83	4
Sept. 1	do	2.50	3
Sept. 28	do	2.33	1
Dec. 30	do	3.33	6
1901.			
Jan. 30	S. G. Bennett	4	1,3
Mar. 2	do	6.8	6,7
Apr. 3	do	5	3,3
July 31	do	5.67	3,9
Oct. 16	do	2.25	5
1902.			
May 14	S. G. Bennett	7.35	7,5
Sept. 11	L. M. Lawson		2

a Gage height at beginning, 6.75; at ending, 7.25

Discharge measurements of San Joaquin River, Fresno County.

Date.	Hydrographer.	Discharge.	Locality.
1899.		*Sec.-feet.*	
Sept. 8	S. G. Bennett	269	500 feet above Pollasky Bridge.
1900.			
Sept. 28	S. G. Bennett	188	Do.
Sept. 28	J. S. Eastwood	188	
1901.			
Oct. 16	S. G. Bennett	315	At Pollasky Ford.
1900.			
Aug. 31	E. G. Hamilton	31	South Fork at Blaney Meadows.
1902.			
Sept. 27	S. G. Bennett	589	Above railroad bridge near Lathrop, San Joaquin County.
Sept. 6	E. T. Perkins	.7	Granite Creek 100 feet below sheep bridge.
Sept. 7	do	342	150 yards below junction Jackass Creek.
Sept. 7	do	3	Jackass Creek 50 feet above junction with San Joaquin.
Sept. 8	do	148	Middle Fork 100 yards above Miller Bridge.
Sept. 10	do	51	Mono Creek at Trail Crossing.
Sept. 10	do	107	South Fork at Trail Crossing.
Sept. 10	do	9	Big Creek at dam site of J. S. Eastwood.
Sept. 8	L. M. Lawson	309	Pollasky.
Sept. 9	do	18	Canal at Reservoir, North Fork, at San Joaquin power house.
Sept. 10	do	310	San Joaquin Electric Co.'s power house.
Sept. 12	do	25	Below dam at Mendota.
Sept. 12	do	260	Miller and Lux Canal at small dam.
Sept. 12	do	265	Miller and Lux canal at bridge near dredger.

Estimated monthly discharge of San Joaquin River at Hamptonville, Fresno County.

[Drainage area, 1,637 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1878.[a]	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
November			330	19,636	0.20	
December			410	25,210	.25	
1879.[a]						
January	3,010	370	609	37,446	0.37	
February	5,420	620	1,276	70,865	.78	
March	3,340	1,300	1,953	120,085	1.19	
April	8,560	2,360	3,849	229,031	2.35	
May	10,030	2,850	5,302	326,007	3.24	
June	11,640	4,200	6,379	379,576	3.90	
July	4,460	1,300	2,303	141,606	1.41	
August	1,300	550	786	48,329	.48	
September	480	310	381	22,671	.23	
October	480	260	373	22,935	.23	
November	420	370	411	24,456	.25	
December	4,700	700	1,140	70,096	.70	
The year	11,640	260	2,063	1,493,103	1.26	17
1880.[a]						
January	1,020	770	825	50,727	0.50	
February	2,360	770	942	54,184	.57	
March	1,640	1,120	1,229	75,568	.75	
April	15,580	1,300	4,846	288,357	2.96	
May	25,000	5,420	13,170	809,792	8.05	
June	25,600	14,180	18,120	1,078,214	11.07	
July	14,650	3,350	8,010	492,516	4.89	
August	4,700	840	1,730	106,374	1.06	
September	840	550	734	43,676	.45	
October	480	380	422	25,948	.26	
November	450	370	380	22,612	.23	
December	6,730	395	2,001	123,037	1.22	
The year	25,600	370	4,367	3,171,005	2.67	

[a] Authority, California State engineering department.

Estimated monthly discharge of San Joaquin River at Hamptonville, Fresno County—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1881.[a]	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	59,800	1,024	3,856	237,096	2.35	2.71
February	22,450	2,440	6,340	352,106	3.87	4.03
March	6,570	2,440	2,855	175,547	1.74	2.01
April	13,250	5,900	8,008	476,509	4.89	5.45
May	16,500	5,900	9,095	559,230	5.56	6.41
June	9,230	4,300	5,948	353,931	3.63	4.05
July	5,180	2,200	3,064	188,398	1.87	2.16
August	1,640	760	1,260	77,474	.77	.89
September	760	490	584	34,750	.36	.40
October	490	430	463	28,469	.28	.32
November	530	380	461	27,431	.28	.31
December	2,740	340	632	38,860	.39	.45
The year	59,800	340	3,547	2,549,801	2.17	29.19
1882.[a]						
January	330	290	303	18,631	0.19	0.22
February	520	280	330	18,327	.20	.21
March	3,890	340	1,522	93,584	.93	1.07
April	7,360	2,540	3,409	202,849	2.08	2.32
May	12,860	7,360	8,850	544,165	5.41	6.23
June	13,980	4,280	7,867	468,119	4.81	5.36
July	6,900	700	2,918	179,421	1.78	2.05
August	1,630	450	591	36,339	.36	.42
September [b]	----------	----------	240	14,281	.15	.17
October [b]	----------	----------	564	34,679	.34	.39
November [b]	----------	----------	490	29,157	.30	.33
December [b]	----------	----------	320	19,676	.20	.23
The year	----------	----------	2,370	1,659,228	1.40	19.00

[a] Authority, California State engineering department.
[b] Estimated from previous measurements and neighboring streams.

Estimated monthly discharge of San Joaquin River at Hamptonville, Fresno County—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1883.[a]	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
January[b]			320	19,676	0.20	0.2
February[b]			320	17,771	.20	.2
March[b]			1,150	70,711	.70	.8
April[b]			2,130	126,744	1.30	1.45
May[b]			7,370	453,164	4.50	5.19
June[b]			6,220	370,116	3.80	4.24
July[b]			1,470	90,387	.90	1.04
August[b]			490	30,129	.30	.35
September[b]			410	24,397	.25	.28
October[b]			330	20,291	.20	.23
November[b]			250	14,876	.15	.17
December[b]			250	15,372	.15	.17
The year			1,726	1,253,634	1.05	14.17
1884.[a]						
January[b]			410	25,210	0.25	0.29
February[b]			2,460	141,501	1.50	1.68
March[b]			4,090	251,484	2.50	2.88
April[b]			3,270	194,578	2.00	2.23
May[b]			8,190	503,583	5.00	5.76
June[b]			16,400	975,868	10.02	11.18
July[b]			13,100	805,488	8.00	9.22
August[b]			3,270	201,064	2.00	2.31
September[b]			980	58,314	.60	.67
October[b]			820	50,420	.50	.58

[a] Authority, California State engineering department.
[b] Estimated from previous measurements and neighboring streams.

Estimated monthly discharge of San Joaquin River at Herndon, Fresno County.

[Drainage area, 1,637 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1895.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	11,225	1,260	2,881	177,146	1.76	2.03
February	8,500	909	2,568	142,619	1.57	1.63
March	9,318	1,554	2,779	170,874	1.70	1.96
April	9,863	3,354	5,834	347,147	3.56	3.97
May	19,960	5,100	13,124	806,963	8.02	9.24
June	14,250	7,250	10,674	635,147	6.52	7.27
July	8,000	2,148	4,528	278,416	2.77	3.20
August	2,301	793	1,417	87,128	.87	1.00
September	8,500	260	1,035	64,562	.66	.73
October	1,260	260	420	25,825	.26	.30
November	426	260	362	21,540	.22	.24
December	677	260	373	22,935	.23	.26
The year	19,960	260	3,837	2,780,302	2.35	31.83
1896.						
January	12,800	250	2,119	130,335	1.29	1.49
February	1,750	950	1,177	67,696	.72	.77
March	12,176	1,180	2,612	160,649	1.60	1.84
April	5,648	1,920	2,675	159,192	1.64	1.83
May	18,800	2,560	5,394	331,700	3.30	3.81
June	16,920	6,544	11,799	702,106	7.21	8.00
July	8,080	1,600	4,177	256,865	2.55	3.04
August	1,300	700	1,048	64,463	.64	.74
September	1,180	80	534	31,817	.33	.37
October	700	80	167	10,275	.10	.12
November	2,390	430	697	41,492	.43	.48
December	1,750	430	666	40,957	.41	.47
The year	18,800	80	2,756	1,997,547	1.69	22.96

Estimated monthly discharge of San Joaquin River at Herndon, Fresno County—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1897.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	1,180	535	655	40,275	0.40	[illegible]
February	15,660	1,180	2,598	144,286	1.59	[illegible]
March	4,600	1,675	2,325	142,960	1.42	[illegible]
April	11,708	2,805	6,541	389,216	4.00	[illegible]
May	18,600	9,565	13,545	832,855	8.27	[illegible]
June	12,332	2,390	5,862	348,812	3.57	[illegible]
July	4,300	1,800	2,493	153,290	1.52	[illegible]
August	1,300	590	898	55,216	.55	[illegible]
September	535	105	227	13,507	.14	[illegible]
October	820	105	279	17,155	.17	[illegible]
November	4,300	120	872	51,887	.53	[illegible]
December	4,000	[a]513	995	61,180	.61	[illegible]
The year	18,600	105	3,108	2,250,639	1.90	[illegible]
1898.						
January	763	530	658	40,459	0.40	[illegible]
February	1,425	530	842	46,762	.51	[illegible]
March	1,242	763	908	55,831	.56	[illegible]
April	5,846	1,018	2,944	175,180	1.80	[illegible]
May	5,141	2,262	3,206	197,131	1.96	[illegible]
June	3,744	1,730	2,718	161,732	1.66	[illegible]
July	1,730	530	959	58,967	.59	[illegible]
August	610	350	480	29,514	.29	[illegible]
September	1,882	220	363	21,600	.22	[illegible]
October	763	350	509	31,297	.31	[illegible]
November	350	290	308	18,327	.19	[illegible]
December	1,181	240	384	23,611	.24	[illegible]
The year	5,846	220	1,190	860,411	.73	[illegible]

[a] Minimum of 60 second-feet given in Nineteenth Ann. Rept. is error.

Estimated monthly discharge of San Joaquin River at Herndon, Fresno County—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1899.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	1,170	170	463	28,469	0.28	0.32
February	1,060	350	645	35,821	.39	.41
March	16,206	692	2,689	165,341	1.64	1.89
April	7,354	2,030	4,233	251,880	2.59	2.88
May	7,090	1,830	3,730	229,350	2.28	2.63
June	9,070	2,620	5,700	339,173	3.48	3.88
July	3,105	955	1,664	104,284	1.02	1.18
August	745	250	428	26,317	.26	.30
September	220	70	152	9,045	.09	.10
October	776	69	214	13,158	.13	.15
November	1,175	130	565	33,620	.34	.39
December	4,775	220	1,018	62,595	.62	.71
The year	16,206	69	1,792	1,299,053	1.09	14.84
1900.						
January	15,932	745	2,244	137,978	1.37	1.58
February	745	355	534	29,657	.33	.34
March	2,780	640	1,748	107,480	1.07	1.23
April	2,780	1,520	2,060	122,578	1.26	1.41
May	9,730	2,170	5,725	352,016	3.50	4.04
June	8,674	3,620	5,728	340,840	3.50	3.90
July	3,445	630	1,642	100,962	1.00	1.15
August	630	240	390	23,980	.24	.28
September	240	180	204	12,139	.13	.14
October	990	180	451	27,730	.28	.32
November	20,780	240	1,834	109,130	1.12	1.25
December	1,285	745	1,033	63,517	.63	.72
The year	20,780	180	1,966	1,428,007	1.20	16.36

Estimated monthly discharge of San Joaquin River at Herndon, Fresno County—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
January	21,372	810	3,506	215,576	2.14	2.47
February	12,940	1,550	4,983	276,742	3.04	3.17
March	6,830	2,480	4,191	257,695	2.56	2.95
April	12,400	1,930	4,680	278,479	2.86	3.19
May	17,870	4,775	10,935	672,367	6.68	7.71
June	15,662	7,882	11,998	713,930	7.33	8.17
July	14,294	3,110	3,466	213,116	2.12	2.45
August	5,850	500	2,373	145,910	1.45	1.67
September	500	360	399	23,742	.24	.27
October	2,480	340	489	30,067	.30	.35
November	1,550	500	702	41,772	.43	.48
December	2,060	460	872	53,617	.53	.61
The year	21,372	340	4,050	2,923,013	2.47	33.49

Discharge measurements of Chiquita San Joaquin River, Madera County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Sept. 27, 1900	J. S. Eastwood	21.6

SAN JOSE CREEK.

Discharge measurements of San Jose Creek, Santa Barbara County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Aug. —, 1889	G. F. Wright	4.3

The following measurements of San Jose Creek were made by Charles J. Johansen for the Pacific Improvement Company. The pipe line along the West Fork of San Jose Creek was not carrying water in the year 1890.

The point of measurement of the West Fork was a short distance bove its junction with the East Fork, or main stream. The main tream, or East Fork, of San Jose Creek was gaged a short distance bove its junction with the West Fork, and the pipe line along this tream was not carrying water in the year 1890.

List of discharge measurements of San Jose Creek, Santa Barbara County.

Date.	Hydrographer.	Discharge.	Locality.
1890.		*Sec.-feet.*	
Feb. 4	Charles J. Johansen	1.57	West Fork at mouth.
Feb. 15	do	.54	Do.
Feb. 28	do	.94	Do.
Mar. 1	do	.60	Do.
Mar. 3	do	.60	Do.
Mar. 5	do	.54	Do.
Mar. 7	do	.54	Do.
Mar. 9	do	.50	Do.
Mar. 11	do	.50	Do.
Mar. 13	do	.44	Do.
Mar. 15	do	.44	Do.
Mar. 17	do	.44	Do.
Mar. 19	do	.50	Do.
Mar. 21	do	.44	Do.
Mar. 23	do	.40	Do.
Mar. 25	do	.40	Do.
Mar. 27	do	.40	Do.
Mar. 29	do	.40	Do.
Mar. 31	do	.40	Do.
Apr. 2	do	.40	Do.
Apr. 4	do	.40	Do.
Apr. 6	do	.40	Do.
Apr. 8	do	.40	Do.
Apr. 10	do	.35	Do.
Apr. 12	do	.40	Do.
Apr. 14	do	.40	Do.
Apr. 15	do	.32	Do.
Apr. 17	do	.29	Do.
Apr. 19	do	.32	Do.
Apr. 21	do	.32	Do.
Apr. 23	do	.32	Do.
Apr. 25	do	.32	Do.
Apr. 27	do	.32	Do.
Apr. 29	do	.35	Do.

List of discharge measurements of San Jose Creek, etc.—Continued.

Date.	Hydrographer.	Discharge.	Locality.
1890.		*Sec.-feet.*	
May 1	Charles J. Johanson	0.32	West Fork at mouth.
May 3	do	.26	Do.
May 5	do	.32	Do.
May 7	do	.32	Do.
May 9	do	.26	Do.
May 11	do	.26	Do.
May 12	do	.23	Do.
May 13	do	.26	Do.
May 15	do	.23	Do.
May 17	do	.26	Do.
May 19	do	.26	Do.
May 21	do	.23	Do.
May 23	do	.23	Do.
May 25	do	.23	Do.
May 27	do	.23	Do.
May 29	do	.23	Do.
May 31	do	.21	Do.
June 2	do	.21	Do.
June 4	do	.21	Do.
June 6	do	.21	Do.
June 8	do	.18	Do.
June 10	do	.23	Do.
June 12	do	.21	Do.
June 14	do	.21	Do.
June 16	do	.27	Do.
June 18	do	.21	Do.
June 20	do	.19	Do.
June 22	do	.21	Do.
June 24	do	.17	Do.
June 26	do	.19	Do.
June 28	do	.20	Do.
June 30	do	.20	Do.
July 2	do	.17	Do.
July 4	do	.17	Do.
July 6	do	.18	Do.
July 8	do	.17	Do.
July 10	do	.17	Do.
July 12	do	.17	Do.
July 14	do	.16	Do.

List of discharge measurements of San Jose Creek, etc.—Continued.

Date.	Hydrographer.	Discharge.	Locality.
1890.		*Sec.-feet.*	
ıly 16	Charles J. Johansen	0.16	West Fork at mouth.
ıly 18	do	.14	Do.
ıly 20	do	.16	Do.
ıly 22	do	.14	Do.
ıly 24	do	.17	Do.
ıly 26	do	.16	Do.
ıly 28	do	.17	Do.
ıly 30	do	.17	Do.
ug. 1	do	.17	Do.
ug. 2	do	.17	Do.
ug. 3	do	.17	Do.
ug. 4	do	.17	Do.
ug. 6	do	.17	Do.
ug. 8	do	.17	Do.
ar. 1	do	6.38	East Fork above West Fork.
ar. 3	do	5.76	Do.
ar. 5	do	5.17	Do.
ar. 7	do	4.88	Do.
ar. 9	do	4.59	Do.
ar. 11	do	4.08	Do.
ar. 13	do	3.76	Do.
ar. 15	do	3.51	Do.
ar. 17	do	3.00	Do.
ar. 19	do	3.51	Do.
ar. 21	do	5.11	Do.
ar. 23	do	4.59	Do.
ar. 25	do	4.59	Do.
ar. 27	do	4.31	Do.
ar. 29	do	4.31	Do.
ar. 31	do	4.08	Do.
pr. 2	do	4.08	Do.
pr. 4	do	3.51	Do.
pr. 6	do	3.51	Do.
pr. 8	do	3.51	Do.
pr. 10	do	3.25	Do.
pr. 12	do	3.00	Do.
pr. 14	do	3.00	Do.
pr. 15	do	1.97	Do.
pr. 17	do	2.24	Do.

List of discharge measurements of San Jose Creek, etc.—Continued.

Date.	Hydrographer.	Discharge.	Locality.
1890.		*Sec.-feet.*	
Apr. 19	Charles J. Johansen	2.10	East Fork above West Fork.
Apr. 21	do	2.10	Do.
Apr. 23	do	1.97	Do.
Apr. 25	do	1.97	Do.
Apr. 27	do	1.97	Do.
Apr. 29	do	2.10	Do.
May 1	do	1.97	Do.
May 3	do	1.72	Do.
May 5	do	1.72	Do.
May 7	do	1.72	Do.
May 9	do	1.72	Do.
May 11	do	1.72	Do.
May 12	do	1.18	Do.
May 13	do	1.59	Do.
May 15	do	1.47	Do.
May 17	do	1.47	Do.
May 19	do	1.47	Do.
May 21	do	1.19	Do.
May 23	do	1.19	Do.
May 25	do	1.25	Do.
May 27	do	1.19	Do.
May 29	do	1.19	Do.
May 31	do	1.19	Do.
June 2	do	1.12	Do.
June 4	do	.94	Do.
June 6	do	.88	Do.
June 8	do	.91	Do.
June 10	do	.91	Do.
June 12	do	.94	Do.
June 14	do	1.00	Do.
June 16	do	1.12	Do.
June 18	do	1.06	Do.
June 20	do	1.00	Do.
June 22	do	.82	Do.
June 24	do	.82	Do.
June 26	do	.88	Do.
June 28	do	.94	Do.
June 30	do	.82	Do.
July 2	do	.76	Do.

List of discharge measurements of San Jose Creek, etc.—Continued.

Date.	Hydrographer.	Discharge.	Locality.
1890.		*Sec.-feet.*	
uly 4	Charles J. Johansen	0.76	East Fork above West Fork.
uly 6	do	.79	Do.
uly 8	do	.76	Do.
uly 10	do	.71	Do.
uly 12	do	.73	Do.
uly 14	do	.70	Do.
uly 16	do	.70	Do.
uly 18	do	.65	Do.
uly 20	do	.62	Do.
uly 22	do	.60	Do.
uly 24	do	.60	Do.
uly 26	do	.63	Do.
uly 28	do	.54	Do.
uly 30	do	.60	Do.
ug. 1	do	.63	Do.
ug. 2	do	.63	Do.
ug. 3	do	.63	Do.
ug. 4	do	.63	Do.
ug. 6	do	.63	Do.
ug. 8	do	.63	Do.
ug. 11	do	.88	Do.
ug. 13	do	.88	Do.
ug. 15	do	.82	Do.
ug. 17	do	.65	Do.
ug. 19	do	.60	Do.
ug. 21	do	.60	Do.
ug. 23	do	.60	Do.
ug. 25	do	.65	Do.
ug. 27	do	.65	Do.
ug. 29	do	.60	Do.
ug. 31	do	.60	Do.
ept. 2	do	.57	Do.
ept. 4	do	.40	Do.
ept. 6	do	44	Do.
ept. 8	do	.57	Do.
ept. 10	do	.44	Do.
ept. 12	do	.54	Do.
ept. 14	do	.50	Do.

List of discharge measurements of San Jose Creek, etc.—Continued.

Date.	Hydrographer.	Discharge.	Locality
1890.		*Sec.-feet.*	
Sept. 15	Charles J. Johansen	0.60	East Fork above West Fork.
Sept. 18	do	.60	Do.
Sept. 20	do	.65	Do.
Sept. 22	do	.60	Do.
Sept. 24	do	.71	Do.
Sept. 26	do	.71	Do.
Sept. 28	do	.82	Do.
Sept. 30	do	.71	Do.
Oct. 2	do	.71	Do.
Oct. 4	do	.68	Do.
Oct. 6	do	.60	Do.
Oct. 7	do	.61	Do.

SAN LUIS REY RIVER.

Discharge measurements of San Luis Rey River, San Diego County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
June 20, 1899	S. G. Bennett	1.04	Headworks Escondido Irrigation District canal.
Aug. 19, 1900	H. N. Savage	2.00	Do.
Sept. —, 1899	do	2.50	4 miles east of Sicklers Mill. Pass
Sept. —, 1899	do	[a] 3.50	
Apr. 2, 1900	do	10.00	Do.
May —, 1894	E. F. Tabor	6.716	
Oct. —, 1894	do	4	
Dec. 8, 1894	do	10	
Dec. 20, 1894	do	240	
Jan. 15, 1895	do	5,000	
Mar. 8, 1895	do	152	
Apr. 11, 1895	do	100	
Apr. 17, 1895	do	72	
May 10, 1895	do	39	
May 19, 1895	do	19	

[a] H. N. Savage states this to be minimum prior to September, 1899.

SAN MATEO CREEK.

San Francisco obtains its domestic water supply from a series of mpounding reservoirs located in the southern portion of the peninsula etween San Francisco Bay and the Pacific Ocean. The drainage asin of these reservoirs ranges in elevation from 250 to 1,800 feet, vith an average of about 750 feet. The hills are undulating. There s a limited growth of timber on the northern slopes near the summit, ut a large amount of brush covers other portions of the basin. On he southern slopes and crests the hills are frequently bare of brush, ut are covered with grasses. The Spring Valley Water Company wns the entire area of the drainage basin and protects the forest overing, not even permitting grazing within its limits. Mr. Herman chussler, chief engineer of the water company, has furnished this ffice with a statement of the rainfall and run-off of the drainage asins which contribute to the water supply under the control of the ompany. The table given below extends from 1869 to 1899, and hows the seasonal rainfall, together with the percentage collected n the reservoirs. The record is therefore thirty years in length. t is by far the oldest table of run-off in the State, and for this eason is of unusual value. The seasonal year rather than the calen- ar is given. Column No. 1 shows the year; column No. 2 the inches f rainfall in the respective basins; column No. 3 the percentage of his rainfall which is caught and delivered, the evaporation being educted. The portion of the discharge table marked "Southeasterly ortion of the watershed southeast of old dam," etc., refers to the rea above the reservoir, which was constructed at an early date. At later period, at a point lower down the stream, the Crystal Springs am was constructed and flooded water over the top of the original am and into the valleys of other streams. This explains the change n the description of the drainage basin which occurs in 1888. The ortion of the table marked "Above southeasterly and northeasterly ortion of peninsula watershed, total Crystal Lake drainage," is for he entire area above the Crystal Springs gage datum. The remark- ble variation in percentage strikingly illustrates the necessity for toring water from the drainage basins in order to provide for periods f drought. In the western portion of the drainage basin there was ractically no run-off in the season of 1876–77, and in the easterly por- ion of the basin there was practically no run-off in the seasons of 881–82, 1882–83, and 1897–98. It would therefore be necessary to tore enough water in the reservoirs to furnish a supply for two ummers and at least one winter. Another feature of interest in his table is that while the run-off in the seasons of 1881–82 and 882–83 was practically nothing from the easterly portion of the basin, he percentage of rainfall in the western portion of the watershed was 9.4 and 23, respectively.

Rainfall and run-off from basin of San Mateo Creek, California.

Year.	Rainfall.	Run-off.
Western portion of peninsula watershed:	*Inches.*	*Per cent.*
1869-70	41.95	22.6
1870-71	34.70	9.8
1871-72	80.42	31.4
1872-73	39.31	28.4
1873-74	48.88	29.5
1874-75	44.26	21.2
1875-76	69.24	39.2
1876-77	23.83	.7
1877-78	72.51	37.8
1878-79	56.10	29.2
1879-80	56.14	35.0
1880-81	53.81	43.0
1881-82	34.23	29.4
1882-83	33.89	23.0
1883-84	54.99	33.2
1884-85	38.25	30.0
1885-86	51.90	43.9
1886-87	34.44	29.1
1887-88	37.53	29.2
1888-89	41.17	28.1
1889-90	73.67	44.7
1890-91	37.69	22.8
1891-92	43.10	13.3
1892-93	58.25	24.4
1893-94	54.90	21.8
1894-95	66.93	25.2
1895-96	49.45	21.0
1896-97	50.47	34.0
1897-98	26.26	9.6
1898-99	42.56	17.7
Total	1,450.83	808.2
Mean	48.36	26.94

Year.	Rainfall.	Run-off.
Southeasterly portion of peninsula watershed (southeast from old dam):	*Inches.*	*Per cent.*
1877-78	57.70	[illegible]
1878-79	43.12	[illegible]
1879-80	48.01	[illegible]
1880-81	38.78	[illegible]
1881-82	25.02	[illegible]
1882-83	23.06	[illegible]
1883-84	40.32	[illegible]
1884-85	25.67	[illegible]
1885-86	35.58	[illegible]
1886-87	28.61	[illegible]
1887-88	32.96	[illegible]
1888-89	35.70	[illegible]
Total	434.53	[illegible]
Mean	36.21	[illegible]
Above southeasterly and northeasterly portions of peninsula watershed, total Crystal Lake drainage:		
1889-90	72.68	[illegible]
1890-91	31.92	[illegible]
1891-92	24.16	[illegible]
1892-93	47.07	[illegible]
1893-94	33.08	[illegible]
1894-95	55.77	[illegible]
1895-96	32.62	[illegible]
1896-97	35.62	[illegible]
1897-98	18.17	[illegible]
1898-99	30.37	[illegible]
Total	381.46	[illegible]
Mean	38.15	[illegible]

SAN ROQUI CREEK.

San Roqui Creek was measured during the year 1890 by Charles J Johansen for the Pacific Improvement Company. The point of measurement was a short distance below the San Roqui tunnel which was being built from 1899 to 1901, the point of measurement being near an old dam in the stream. This drainage line is called San Roqui Creek in its mountainous portions, but lower down and south of the Southern Pacific Railroad it is called the Arroyo Bur[illegible]

List of discharge measurements of San Roqui Creek, Santa Barbara County.

Date.	Hydrographer.	Discharge.	Locality.
1890.		*Sec.-feet.*	
Feb. 13	Charles J. Johansen	4.96	At old diversion box below tunnel.
Feb. 19	do	5.70	Do.
Feb. 21	do	9.61	Do.
Feb. 26	do	11.03	Do.
Mar. 1	do	6.91	Do.
Mar. 3	do	6.28	Do.
Mar. 5	do	5.67	Do.
Mar. 6	do	5.67	Do.
Mar. 8	do	5.20	Do.
Mar. 10	do	5.20	Do.
Mar. 12	do	4.96	Do.
Mar. 14	do	4.96	Do.
Mar. 16	do	4.27	Do.
Mar. 18	do	4.27	Do.
Mar. 20	do	4.73	Do.
Mar. 22	do	4.73	Do.
Mar. 24	do	4.27	Do.
Mar. 26	do	3.84	Do.
Mar. 28	do	3.84	Do.
Mar. 30	do	3.84	Do.
Apr. 1	do	3.42	Do.
Apr. 3	do	3.42	Do.
Apr. 5	do	3.42	Do.
Apr. 7	do	3.21	Do.
Apr. 9	do	3.21	Do.
Apr. 11	do	3.00	Do.
Apr. 13	do	2.80	Do.
Apr. 15	do	2.62	Do.
Apr. 17	do	2.62	Do.
Apr. 19	do	2.42	Do.
Apr. 21	do	2.15	Do.
Apr. 23	do	1.88	Do.
Apr. 25	do	1.80	Do.
Apr. 27	do	1.80	Do.
Apr. 29	do	1.55	Do.
May 1	do	1.55	Do.
May 3	do	1.39	Do.
May 5	do	1.39	Do.
May 7	do	1.39	Do.
May 9	do	1.23	Do.
May 11	do	1.23	Do.

List of discharge measurements of San Roqui Creek, etc.—Continued.

Date.	Hydrographer.	Discharge.	Locality.
1890.		*Sec.-feet.*	
May 13	Charles J. Johansen	1.30	At old diversion box below tunnel
May 15	do	1.23	Do.
May 17	do	1.23	Do.
May 19	do	1.23	Do.
May 20	do	.63	Do.
May 22	do	.65	Do.
May 24	do	.65	Do.
May 26	do	.65	Do.
May 28	do	.54	Do.
May 30	do	.54	Do.
June 2	do	.52	Do.
June 4	do	.52	Do.
June 5	do	.44	Do.
June 7	do	.40	Do.
June 9	do	.35	Do.
June 11	do	.35	Do.
June 13	do	.35	Do.
June 15	do	.35	Do.
June 17	do	.38	Do.
June 19	do	.38	Do.
June 21	do	.38	Do.
June 23	do	.38	Do.
June 25	do	.35	Do.
June 27	do	.35	Do.
June 29	do	.29	Do.
July 1	do	.29	Do.
July 3	do	.29	Do.
July 5	do	.29	Do.
July 7	do	.29	Do.
July 9	do	.29	Do.
July 11	do	.26	Do.
July 13	do	.26	Do.
July 15	do	.26	Do.
July 17	do	.26	Do.
July 19	do	.23	Do.
July 21	do	.20	Do.
July 23	do	.20	Do.
July 25	do	.20	Do.
July 27	do	.20	Do.
July 29	do	.20	Do.
July 31	do	.24	Do.

List of discharge measurements of San Roqui Creek, etc.—Continued.

Date.	Hydrographer.	Discharge.	Locality.
1890.		*Sec.-feet.*	
Aug. 2	Charles J. Johansen	0.24	At old diversion box below tunnel.
Aug. 4	do	.24	Do.
Aug. 6	do	.24	Do.
Aug. 8	do	.26	Do.
Aug. 10	do	.26	Do.
Aug. 12	do	.26	Do.
Aug. 14	do	.23	Do.
Aug. 16	do	.23	Do.
Aug. 18	do	.20	Do.
Aug. 19	do	.20	Do.
Aug. 22	do	.17	Do.
Sept. 2	do	.19	Do.
Sept. 3	do	.19	Do.
Sept. 4	do	.19	Do.
Sept. 5	do	.19	Do.
Sept. 6	do	.19	Do.
Sept. 7	do	.19	Do.
Sept. 8	do	.19	Do.
Sept. 10	do	.19	Do.
Sept. 11	do	.19	Do.
Sept. 12	do	.19	Do.
Sept. 13	do	.19	Do.
Sept. 14	do	.19	Do.
Aug. 26	do	.09	Below old diversion box.
Aug. 28	do	.09	Do.
Aug. 30	do	.07	Do.
Sept. 2	do	.04	Do.
Sept. 4	do	.04	Do.
Sept. 6	do	.05	Do.
Sept. 8	do	.04	Do.
Sept. 10	do	.04	Do.
Sept. 12	do	.04	Do.
Sept. 14	do	.04	Do.

SANTA ANA RIVER.

The river has its source on the southwestern slope of the San Bernardino Mountains and flows west, appearing from its canyon 6 miles northeast of Redlands. Its waters are completely used in San Bernardino Valley. At the lower part of the valley the water appears again in the vicinity of Rincon, where the river passes through a

comparatively narrow gorge, and the stream flows thence in a gener southwesterly direction, emptying into the Pacific Ocean. The sta tion, established June, 1896, is located 5 miles northeast of Mento Cal., three-fourths of a mile below the head works of the Santa A canal and opposite the warm springs in the canyon. The gage is inclined timber fastened to a large bowlder and posts set in the ban of the river. On October 16, 1898, owing to some local legal comp cations, an unusually large volume of water was turned into the San Ana canal by the Bear Valley Company. This water was waste from the canal at a point below the old gage rod, necessitating th establishment of a new gage rod upon this stream at a point belo where the waste from the canal was turned into the river. The new gage was put in November 9, 1898, and since that date daily observa tions have been kept on the lower gage, which is a 2 by 6 inch timb firmly bolted to a granite cliff, which forms the left bank of the river and is situated 800 feet below the mouth of Warmsprings Canyo and 100 feet above a ford on the canyon road. A landslide occurre below the gage rod April 16, 1899, which changed the condition of th rating for the station. Owing to the shifting nature of the stream bed it has not been possible to construct perfectly satisfactory ratin curves, but the tables as presented are based on the best information that could be obtained. This river is one of the most difficul streams in the State to accurately gage. The Edison Electric Com pany diverts the greater portion of the water of Santa Ana River above the gaging station, but also returns all of it above the station Only limited portions of the water are allowed to pass out of the con duits during certain hours of the day, the water being held back for the purpose of obtaining additional power when the greatest demand exists. An effort is being made to arrange with this company to obtain a record of the number of gates, the sizes of the openings, and the hours at which the various wheels are run, in order to more accurately determine the volumes of water. The Santa Ana canal, as mentioned above, also diverts water from Santa Ana River above the station, but the greater part of it is returned to the channel of the stream before passing the point of measurement.

It was found that this station could not be used during high water, and on January 1, 1901, observations were resumed at the old station and on Santa Ana Canal near the river station.

From June 1 to December 31, 1901, and for the entire year 1902, except from February 26 to April 23, inclusive, the discharge of Santa Ana River was obtained by observations on the weirs at the head works of Green Spot pipe line, Highlands canal, and Redlands canal. The flow from Redlands tunnel and Morton Canyon was assumed to offset the loss by evaporation between the old gaging station and the mouth of the canyon.

The drainage area used prior to 1902 was obtained from Land Office maps. Subsequently the Geological Survey completed its contour

ap of this basin and an area of 182 square miles above the gaging ation was obtained therefrom and was accepted.

Discharge measurements of Alder Creek, a branch of Santa Ana River, San Bernardino County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
ugust 8, 1897	A. Q. Campbell	0.88
ugust 31, 1897	do	1.00
ovember 14, 1897	J. B. Lippincott	2.00
pril 14, 1900	S. G. Bennett	1.90
tober 8, 1901	do	.89

ischarge measurements of Santa Ana River above mouth of Bear Creek, San Bernardino County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
ly 27, 1896	J. H. Quinton	14.2
ugust 31, 1897	A. Q. Campbell	17.9
ovember 14, 1897	J. B. Lippincott	17.5

The discharge of the streams of southern California was unusually w in September, 1898, and these measurements were made to deterine this minimum with its hourly fluctuation.

Discharge measurements of Santa Ana River above mouth of Bear Creek.

[Measurements by Edison Electric Company.]

Date.	Discharge.	Date.	Discharge.
pt. 15, 1898:	*Sec.-feet.*	Sept. 15, 1898—Continued.	*Sec.-feet.*
7 a. m	8.22	1.30 p. m	7.12
7.30 a. m	8.22	2 p. m	7.20
8 a. m	8.22	2.30 p. m	7.06
8.30 a. m	8.22	3 p. m	6.92
9 a. m	8.22	3.30 p. m	6.86
9.30 a. m	8.22	4 p. m	6.66
10 a. m	8.46	4.30 p. m	6.98
10.30 a. m	8.10	5 p. m	6.44
11 a. m	7.98	5.30 p. m	6.22
11.30 a. m	7.86	6 p. m	6.22
12 m	7.76	6.30 p. m	6.10
12.30 p. m	7.48	12-hour mean	7.43
1 p. m	7.54		

Discharge measurements of Santa Ana River, etc.—Continued.

Date.	Discharge.
	Sec.-feet.
Sept. 15, 1898—Continued.	
7 p. m	6.10
7.30 p. m	6.10
8 p. m	6.10
8.30 p. m	6.02
9 p. m	6.02
9.30 p. m	6.02
10 p. m	6.02
10.30 p. m	6.02
11 p. m	6.32
11.30 p. m	6.96
12 midnight	6.60
Sept. 16, 1898:	
12.30 a. m	6.66
1 a. m	6.66
1.30 a. m	6.86
2 a. m	6.92
2.30 a. m	7.06
3 a. m	7.20
3.30 a. m	7.32
4 a. m	7.54
4.30 a. m	7.66
5 a. m	7.66
5.30 a. m	7.86
6 a. m	7.76
6.30 a. m	7.76
12-hour mean	6.80
7 a. m	7.76
7.30 a. m	7.76
8 a. m	8.10
8.30 a. m	7.98
9 a. m	8.04
9.30 a. m	8.10
10 a. m	7.82
10.30 a. m	7.98
11 a. m	7.86
11.30 a. m	7.76
12 m	7.48
12.30 p. m	7.44
1 p. m	7.32

Date.	Discharge.
Sept. 16, 1898—Continued.	
1.30 p. m	
2 p. m	
2.30 p. m	
3 p. m	
3.30 p. m	
4 p. m	
4.30 p. m	
5 p. m	
5.30 p. m	
6 p. m	
6.30 p. m	
12-hour mean	
7 p. m	
7.30 p. m	
8 p. m	
8.30 p. m	
9 p. m	
9.30 p. m	
10 p. m	
10.30 p. m	
11 p. m	
11.30 p. m	
12 midnight	
Sept. 17, 1898:	
12.30 a. m	
1 a. m	
1.30 a. m	
2 a. m	
2.30 a. m	
3 a. m	
3.30 a. m	
4 a. m	
4.30 a. m	
5 a. m	
5.30 a. m	
6 a. m	
6.30 a. m	
12-hour mean	

ischarge measurements of Bear Creek above Santa Ana River, San Bernardino County.

[Measurements by Edison Electric Co.]

Date.	Discharge.	Date.	Discharge.
pt. 15, 1898:	*Sec.-feet.*	Sept. 16, 1898:	*Sec.-feet.*
7 a. m	23.30	12.30 a. m	19.74
7.30 a. m	23.30	1 a. m	19.74
8 a. m	23.30	1.30 a. m	19.54
8.30 a. m	25.94	2 a. m	19.34
9 a. m	23.30	2.30 a. m	19.14
9.30 a. m	23.30	3 a. m	18.72
10 a. m	23.30	3.30 a. m	18.72
10.30 a. m	23.10	4 a. m	18.32
11 a. m	23.10	4.30 a. m	18.32
11.30 a. m	22.84	5 a. m	18.12
12 m	22.66	5.30 a. m	18.12
12.30 p. m	22.66	6 a. m	17.92
1 p. m	22.66	6.30 a. m	17.80
1.30 p. m	22.66	12-hour mean	19.84
2 p. m	22.66		
2.30 p. m	22.66	7 a. m	17.92
3 p. m	22.66	7.30 a. m	17.92
3.30 p. m	22.44	8 a. m	17.80
4 p. m	22.44	8.30 a. m	16.94
4.30 p. m	22.44	9 a. m	17.34
5 p. m	22.02	9.30 a. m	17.24
5.30 p. m	22.02	10 a. m	17.12
6 p. m	22.02	10.30 a. m	17.12
6.30 p. m	21.80	11 a. m	16.84
12-hour mean	22.86	11.30 a. m	16.94
		12 m	16.56
7 p. m	21.60	12.30 p. m	16.94
7.30 p. m	21.60	1 p. m	16.76
8 p. m	21.60	1.30 p. m	16.76
8.30 p. m	21.40	2 p. m	16.56
9 p. m	21.06	2.30 p. m	16.56
9.30 p. m	21.18	3 p. m	16.56
10 p. m	20.98	3.30 p. m	16.56
10.30 p. m	20.98	4 p. m	16.38
11 p. m	20.78	4.30 p. m	16.38
11.30 p. m	21.60	5 p. m	16.38
12 midnight	19.94	5.30 p. m	16.38

Discharge measurements of Bear Creek, etc.—Continued.

Date.	Discharge.	Date.	
Sept. 16, 1898—Continued.	*Sec.-feet.*	Sept. 17, 1898:	
6 p. m	16.38	12.30 a. m	
6.30 p. m	16.38	1 a. m	
12-hour mean	16.86	1.30 a. m	
7 p. m	16.38	2 a. m	
7.30 p. m	16.28	2.30 a. m	
8 p. m	16.28	3 a. m	
8.30 p. m	16.28	3.30 a. m	
9 p. m	16.18	4 a. m	
9.30 p. m	16.38	4.30 a. m	
10 p. m	16.38	5 a. m	
10.30 p. m	16.38	5.30 a. m	
11 p. m	16.38	6 a. m	
11.30 p. m	16.38	6.30 a. m	
12 midnight	16.38	12-hour mean	

Discharge measurements of Bear Creek above Santa Ana River, San Bernardino County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
July 27, 1896	J. H. Quinton	
Aug. 31, 1897	A. Q. Campbell	
Nov. 14, 1897	J. B. Lippincott	

Discharge measurements of Green Spot Pipe Line, Santa Ana River, San Bernardino County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
1896.		
Nov. 21	J. B. Lippincott	
1898.		
Jan. 8	J. B. Lippincott	
Apr. 12	do	
Apr. 12	do	
Apr. 29	do	
June 12	do	
July 23	do	
Sept. 8	do	
Oct. 18	F. H. Olmsted	
Nov. 9	do	
Dec. 8	do	
Dec. 8	do	

[a] Intake. [b] Outlet (lower end).

Discharge measurements of Green Spot Pipe Line, etc.—Continued.

Date.	Hydrographer.	Discharge.
1899.		*Sec.-feet.*
ın. 12	S. G. Bennett	0.00
eb. 18	do	[a] 3.53
eb. 18	do	[b] .35
ar. 23	do	3.71
ay 6	do	[a] 1.43
ay 6	do	[b] .62
ay 31	do	.14
ıly 15	do	[a] .59
ıly 15	do	[b] .44
ıly 27	do	[a] .64
ıly 27	do	[b] .54
ıg. 24	do	[b] .28
1900.		
pril 14	S. G. Bennett	2.15
ıly 13	do	[a] 0.00
ct. 2	W. W. Cockins, jr	[a] .12
1901.		
eb. 5	S. G. Bennett	[a] 0.00
ar. 4	do	[a] 2.73
ar. 30	do	[a] 0.00
ıly 6	do	[a] 3.68
ıly 6	do	[b] 3.49
ıg. 20	do	0.00
ct. 8	do	5.77
ec. 5	do	1.65
1902.		
ay 31	S. G. Bennett	[a] 2.70
ay 31	do	[b] 2.50
ıly 10	do	[a] 0.00
ept. 3	W. W. Clapp	[a] 0.00
ov. 5	S. G. Bennett	[a] 2.83

[a] Intake. [b] Outlet (lower end).

Estimated monthly discharge of Bear Valley Water, Green Spot Pipe Line, Santa Ana River, at head of Crafton ditch, San Bernardino County.

Month.	Mean discharge.	Month.	Mean discharge.
1897.	*Sec.-feet.*	1899.	*Sec.-feet.*
August	21.5	July	[illegible]
September	15.8	August	[illegible]
October 1 to 21	13.2	September	[illegible]
1898.		October	[illegible]
April	17.0	November	[illegible]
May	17.2	December	[illegible]
June	13.2	1900.	
July	9.1	January	[illegible]
August	9.1	February	[illegible]
September	8.2	March	[illegible]
October	9.0	April	[illegible]
November	10.0	May	[illegible]
December	10.7	June	[illegible]
1899.		July 1 to 15	[illegible]
January 1 to 9	11.0	August	
February	11.6	September	
March	12.2	October	
April	11.8	November	
May	11.2	December	
June	5.4		

Estimated monthly discharge of Green Spot Pipe Line, Santa Ana River Headworks Weir, San Bernardino County.

Month.	Mean discharge.	Month.	Mean discharge.
1901.	*Sec.-feet.*	1901—Continued.	*Sec.-feet.*
June	1.5	October	[illegible]
July	2.3	November	[illegible]
August	2.7	December	[illegible]
September	5.5		

Discharge measurements of Highlands or North Fork Canal at intake weir, Santa Ana River, San Bernardino County.

Date.	Hydrographer.	Discharge.
1896.		*Sec.-feet.*
Nov. 21	J. B. Lippincott	8.50
1898.		
Jan. 8	J. B. Lippincott	11.91
Mar. 9	H. Crowe	10.76
Apr. 12	J. B. Lippincott	12.40
Apr. 29	do	17.03
June 12	do	11.37
Sept. 8	do	13.29
Oct. 18	F. H. Olmsted	9.85
Nov. 9	do	8.12
Dec. 8	do	6.95
1899.		
Feb. 18	S. G. Bennett	8.07
Mar. 23	do	11.78
May 6	do	7.70
May 31	do	6.74
June 15	do	10.30
July 15	do	13.14
July 27	do	11.92
Aug. 24	do	4.28
1900.		
Apr. 14	S. G. Bennett	7.48
July 13	do	(a)
Oct. 2	W. W. Cockins, jr	5.61
1901.		
July 6	S. G. Bennett	13.28
Aug. 20	do	15.79
Oct. 8	do	14.30
Dec. 5	do	8.53
May 31	do	7.90
1902.		
July 10	S. G. Bennett	11.50
Sept. 3	W. B. Clapp	11.10
Nov. 5	S. G. Bennett	10.02

a Water not going through weir basin; weir was being repaired.

Discharge measurements of Santa Ana River above Keller Creek, San Bernardino County.[a]

[Measurements by Edison Electric Company.]

Date.	Discharge.	Date.	Discharge.
Sept. 15, 1898:	*Sec.-feet.*	Sept. 16, 1898:	
7 a. m	29.30	12.30 a. m	
7.30 a. m	30.44	1 a. m	
8 a. m	23.30	1.30 a. m	
8.30 a. m	30.44	2 a. m	
9 a. m	30.44	2.30 a. m	
9.30 a. m	30.44	3 a. m	
10 a. m	30.44	3.30 a. m	
10.30 a. m	30.44	4 a. m	
11 a. m	30.44	4.30 a. m	
11.30 a. m	30.44	5 a. m	
12 m	29.30	5.30 a. m	
12.30 p. m	29.30	6 a. m	
1 p. m	29.30	6.30 a. m	
1.30 p. m	29.30	12-hour mean	
2 p. m	29.30		
2.30 p. m	29.30	7 a. m	
3 p. m	29.30	7.30 a. m	
3.30 p. m	28.20	8 a. m	
4 p. m	28.20	8.30 a. m	
4.30 p. m	28.20	9 a. m	
5 p. m	28.20	9.30 a. m	
5.30 p. m	28.20	10 a. m	
6 p. m	28.20	10.30 a. m	
6.30 p. m	29.30	11 a. m	
12-hour mean	29.16	11.30 a. m	
		12 m	
7 p. m	29.30	12.30 p. m	
7.30 p. m	28.22	1 p. m	
8 p. m	28.20	1.30 p. m	
8.30 p. m	28.20	2 p. m	
9 p. m	28.20	2.30 p. m	
9.30 p. m	28.20	3 p. m	
10 p. m	28.20	3.30 p. m	
10.30 p. m	28.20	4 p. m	
11 p. m	28.20	4.30 p. m	
11.30 p. m	28.20	5 p. m	
12 midnight	28.20	5.30 p. m	

[a] The discharge of the streams of southern California was unusually low in September and these measurements were made by the Edison Electric Company to determine this minimum with its hourly fluctuation.

Discharge measurements of Santa Ana River, etc.—Continued.

Date.	Discharge.	Date.	Discharge.
pt. 16, 1898—Continued.	*Sec.-feet.*	Sept. 17, 1898:	*Sec.-feet.*
6 p. m	21.80	12.30 a. m	22.80
6.30 p. m	22.80	1 a. m	22.80
12-hour mean	23.74	1.30 a. m	23.86
		2 a. m	23.86
7 p. m	22.80	2.30 a. m	23.86
7.30 p. m	22.80	3 a. m	23.86
8 p. m	22.80	3.30 a. m	23.86
8.30 p. m	23.86	4 a. m	23.86
9 p. m	23.86	4.30 a. m	23.86
9.30 p. m	22.80	5 a. m	23.86
10 p. m	22.80	5.30 a. m	22.80
10.30 p. m	22.80	6 a. m	21.80
11 p. m	22.80	6.30 a. m	22.80
11.30 p. m	22.80	12-hour mean	23.20
12 midnight	22.80		

Discharge measurements of Keller Creek, a tributary of Santa Ana River.

Date.	Hydrographer.	Discharge.
1897.		*Sec.-feet.*
ov. 14	A. Q. Campbell	1.00
1900.		
pr. 14	S. G. Bennett	.67

Discharge measurements of Morton Canyon Water, tributary to Santa Ana River

Date.	Hydrographer.	Discharge.
1898.		Sec.-ft.
Apr. 12	J. B. Lippincott	[illegible]
Apr. 29	....do	[illegible]
June 12	....do	[illegible]
1899.		
May 31	S. G. Bennett	[illegible]
June 15	....do	[illegible]
July 15	....do	[illegible]
Aug. 24	....do	[illegible]
1900.		
Apr. 14	S. G. Bennett	[illegible]
July 13	....do	[illegible]
Oct. 2	W. W. Cockins, jr	[illegible]

Discharge measurements of Redlands or South Fork canal weir at Sand Bar, tributary to Santa Ana River.

Date.	Hydrographer.	Discharge.
1896.		Sec.-ft.
July 29	J. H. Quinton	[illegible]
Nov. 21	J. B. Lippincott	[illegible]
1898.		
Jan. 8	J. B. Lippincott	[illegible]
Mar. 9	H. Crowe	[illegible]
Apr. 12	J. B. Lippincott	[illegible]
Apr. 29	....do	[illegible]
June 12	....do	[illegible]
July 23	....do	[illegible]
Sept. 8	....do	[illegible]
Oct. 18	F. H. Olmsted	[illegible]
Nov. 9	....do	[illegible]
Dec. 8	....do	[illegible]
1899.		
Jan. 12	S. G. Bennett	[illegible]
Feb. 18	....do	[illegible]
Mar. 23	....do	[illegible]
May 6	....do	[illegible]
May 31	....do	[illegible]
June 15	....do	[illegible]
June 27	....do	[illegible]
July 15	....do	[illegible]
Aug. 24	....do	[illegible]

Discharge measurements of Redlands or South Fork canal weir, etc.—Cont'd.

Date.	Hydrographer.	Discharge.
1900.		*Sec.-feet.*
pr. 14	S. G. Bennett	12.10
ıly 13	do	10.65
ct. 2	W. W. Cockins, jr	6.25
1901.		
ar. 30	S. G. Bennett	30.00
ay 31	do	19.60
ıly 6	do	19.91
ug. 20	do	16.75
ct. 8	do	24.10
ec. 5	do	14.27
1902.		
ıly 10	S. G. Bennett	10.06
pt. 3	W. B. Clapp	14.60
ov. 5	S. G. Bennett	7.55

ischarge measurements of Redlands or Bolen tunnel, tributary to Santa Ana River.

Date.	Hydrographer.	Discharge.
1896.		*Sec.-feet.*
ov. 21.	J. B. Lippincott	1.00
1898.		
ne 12	J. B. Lippincott	1.24
pt. 8	do	1.24
1899.		
ne 15	S. G. Bennett	.67
ly 15	do	1.03
ug. 24	do	1.10
1900.		
pr. 14	S. G. Bennett	.88
ly 13	do	.84
ct. 2	W. W. Cockins, jr	.85
1901.		
ly 6	S. G. Bennett	1.40
ec. 5	do	.90
1902.		
ly 10	do	.90

Discharge measurements of Santa Ana Canal, San Bernardino County.[a]

Date.	Hydrographer.	Discharge.
		Sec.-feet.
1896.		
June 20	J. B. Lippincott	18.2
July 28	J. H. Quinton	14.9
Nov. 21	J. B. Lippincott	5.5
1897.		
Jan. 27	J. B. Lippincott	4.0
Mar. 4	do	5.9
June 15	do	19.0
July 1	do	18.3
July 6	A. Q. Campbell	12.4
July 6	do	11.7
Aug. 8	do	18.6
Aug. 31	do	18.-
Sept. 30	do	22.5
Nov. 14	do	7.3
1898.		
Jan. 8	A. Q. Campbell	8.7
Mar. 9	do	7.04
Apr. 2	J. B. Lippincott	12.6
Apr. 12	do	7.6
June 12	do	3.2
July 23	do	3.04
Sept. 8	do	1.6
Oct. 18	F. H. Olmsted	7.2
Nov. 9	do	19.5
Dec. 8	do	20.-
1899.		
Jan. 12	S. G. Bennett	.-
Feb. 18	do	4.-
Mar. 23	do	7.-
May 6	do	6.-
May 31	do	1.-
June 15	do	.-
July 15	do	.-
July 27	do	-
Aug. 24	do	-

[a] For total flow of river and canal see Santa Ana River, total flow.

Discharge measurements of Santa Ana Canal, etc.—Continued.

Date.	Hydrographer.	Discharge.
1901.		*Sec.-feet.*
Mar. 30	S. G. Bennett	3.40
Oct. 8	do	13.20
Dec. 5	do	9.70
1902.		
May 31	S. G. Bennett	20.70
July 10	do	18.5
Sept. 3	W. B. Clapp	14.2
Nov. 5	S. G. Bennett	12.7

Discharge measurements of Santa Ana River and Canal at Warm Spring, San Bernardino County.

Date.	Hydrographer.	Gage height.	Discharge.
1896.		*Feet.*	*Sec.-feet.*
Apr. 27	J. A. Vogleson		51.00
July 25	J. H. Quinton		75.00
June 20	J. B. Lippincott		[a]61.77
Do	do		[b]18.28
	Total		80.05
1896.			
July 28	J. H. Quinton	1.29	[a]59.72
Do	do		[b]14.98
	Total		74.70
Nov. 21	J. B. Lippincott	.98	[a]31.68
Do	do		[b]3.50
	Total		35.18
Nov. 21	J. B. Lippincott		[c]27.40
1897.			
Jan. 27	J. B. Lippincott		[a]43.58
Do	do		[b]4.00
	Total		47.58
Mar. 4	J. B. Lippincott		[a]100.70
Do	do		[b]5.00
	Total		105.70

[a] River. [b] Santa Ana Canal. [c] Total flow at mouth of canyon.

Discharge measurements of Santa Ana River and Canal, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge
1897.		*Feet.*	*Sec.-ft.*
June 15	J. B. Lippincott	1.15	[illegible]
Do	do		[illegible]
	Total		[illegible]
July 1	A. Q. Campbell	1.20	[illegible]
Do	do		[illegible]
	Total		[illegible]
July 6	A. Q. Campbell	1.1	[illegible]
Do	do		[illegible]
	Total		[illegible]
Aug. 8	A. Q. Campbell	1.32	[illegible]
Do	do		[illegible]
	Total		[illegible]
Aug. 8	A. Q. Campbell		[illegible]
Aug. 31	do		[illegible]
Do	do		[illegible]
Sept. 30	do		[illegible]
Do	do	1.13	[illegible]
Do	do		[illegible]
	Total		[illegible]
Nov. 14	A. Q. Campbell	1.25	[illegible]
Do	do		[illegible]
	Total		[illegible]
1898.			
Jan. 8	J. B. Lippincott	1.00	[illegible]
Do	do		[illegible]
	Total		[illegible]
Mar. 9	H. Crowe	1.05	[illegible]
Do	do		[illegible]
	Total		[illegible]

[a] River.
[b] Santa Ana Canal.
[c] Weir above Santa Ana Canal intake.
[d] Meter above Santa Ana Canal intake.

Discharge measurements of Santa Ana River and Canal, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1898.		*Feet.*	*Sec.-feet.*
Mar. 9	H. Crowe		[a] 68.01
Apr. 11	J. B. Lippincott	.98	[b] 31.61
Do	do		[c] 7.67
	Total		39.28
Apr. 29	J. B. Lippincott	.90	[b] 29.67
Do	do		[c] 12.66
	Total		42.33
June 12	J. B. Lippincott	1.10	[b] 35.14
Do	do		[c] 3.92
	Total		39.06
July 23	J. B. Lippincott	1.10	[b] 42.22
Do	do		[c] 5.34
	Total		47.56
Sept. 8	J. B. Lippincott	1.05	[b] 35.01
Do	do		[c] 1.66
	Total		36.67
Oct. 18	F. H. Olmsted	.95	[b] 22.78
Do	do		[c] 7.92
	Total		30.70
Nov. 9	F. H. Olmsted	1.10	[d] 21.78
Dec. 8	do	1.13	[d] 24.74
1899.			
Jan. 12	S. G. Bennett	1.07	[b] 38.00
Do	do		[c] 0
	Total		38.00
Feb. 18	S. G. Bennett	[e] 2.16	[b] 28.04
Do	do		[c] 4.00
	Total		32.04
Mar. 23	S. G. Bennett	2.30	[b] 29.62
Do	do		[c] 7.60
	Total		37.22

[a] Above Santa Ana Canal intake.
[b] River.
[c] Canal.
[d] Total water from Santa Ana Canal wasted above gaging station.
[e] New rod.

Discharge measurements of Santa Ana River and Canal, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-ft.*
May 6	S. G. Bennett	2.45	[illegible]
Do	do		[illegible]
	Total		[illegible]
May 31	S. G. Bennett	2.27	[illegible]
Do	do		[illegible]
	Total		[illegible]
June 15	S. G. Bennett	2.21	[illegible]
Do	do		[illegible]
	Total		[illegible]
July 15	S. G. Bennett	2.30	[illegible]
Do	do		
July 27	do	2.3	[illegible]
Do	do		
Aug. 24	do	1.85	[illegible]
Do	do		
1900.			
Apr. 14	S. G. Bennett	2.35	[illegible]
Do	do		
July 13	S. G. Bennett		[illegible]
Do	do		[illegible]
Nov. 20	do	[c]1.70	[illegible]
Do	do		[illegible]
1901.			
Feb. 5	S. G. Bennett	1.65	[illegible]
Feb. 23	do	1.80	[illegible]
Mar. 4	do	1.70	[illegible]
Mar. 30	do	1.35	[illegible]
Do	do		[illegible]
	Total		[illegible]
July 6	S. G. Bennett	1.15	[illegible]
Do	do		[illegible]
	Total		[illegible]
Do	S. G. Bennett		[illegible]
	Total		[illegible]
Aug. 20	S. G. Bennett	1.24	[illegible]
Do	do		[illegible]

[a] River.
[b] Canal.
[c] Old rod.
[d] Total flow.
[e] Total for canals at mouth of canyon, including tunnel water.
[f] Less tunnel water.
[g] Loss from Warm Springs to mouth of canyon.

Discharge measurements of Santa Ana River and Canal, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Sec-feet.*
Oct. 8	S. G. Bennett	1.25	[a] 32.00
Do	do		[b] 13.20
	Total		45.20
Dec. 5	S. G. Bennett	1.03	[a] 14.00
Do	do		[b] 9.70
	Total		23.70
1902.			
Apr. 5	S. G. Bennett	1.39	[a] 51.00
Do	do		[b] 4.20
	Total		55.20
May 31	S. G. Bennett	.91	[a] 8.30
Do	do		[b] 20.70
	Total		29.00
July 10	S. G. Bennett	.84	[a] 5.00
Do	do		[b] 18.50
	Total		23.50
Sept. 3	W. B. Clapp	.95	[a] 10.00
Do	do		[b] 14.20
	Total		24.20
Nov. 5	S. G. Bennett	.87	[a] 5.30
Do	do		[b] 12.70
	Total		18.00

[a] River. [b] Canal.

Discharge measurements of Santa Ana River at Warm Spring, San Bernardino County.

Date.	Hydrographer.	Gage height.	Discharge.
1896.		*Feet.*	*Sec.-ft.*
June 20	J. B. Lippincott	.....	61
July 28	J. H. Quinton	.....	76
Nov. 21	J. B. Lippincott	.....	31
1897.			
Jan. 27	J. B. Lippincott	.....	42
Mar. 4	....do	.....	10
June 15	....do	1.15	64
July 1	A. Q. Campbell	1.30	73
July 6	....do	1.11	60
Aug. 8	....do	1.32	56
Sept. 30	....do	1.13	43
Nov. 14	....do	1.35	74
1898.			
Jan. 8	A. Q. Campbell	1.00	57
Mar. 9	H. Crowe	1.05	45
Apr. 11	J. B. Lippincott	.98	37
Apr. 29	....do	.90	27
June 12	....do	1.10	45
July 23	....do	1.10	45
Sept. 8	....do	1.05	35
Oct. 18	F. H. Olmsted	.95	25
Nov. 9	....do	1.10	40
Dec. 8	....do	1.13	50
1899.			
Jan. 12	S. G. Bennett	1.07	48
Feb. 18	....do	[a]2.16	96
Mar. 23	....do	2.80	90
May 6	....do	2.45	70
May 31	....do	2.27	60
June 15	....do	2.21	55
July 15	....do	2.30	60
July 27	....do	2.30	57
Aug. 24	....do	1.85	15
1900.			
Apr. 14	S. G. Bennett	2.25	80
May 5	....do	2.20	60
July 13	....do	.....	30
Nov. 20	....do	[b]1.70	15
Nov. 22	....do	.....	10

[a] New rod. [b] Old rod. [c] Calculated.

Discharge measurements of Santa Ana River at Warm Spring, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Sec.-feet.*
Mar. 4	S. G. Bennett	1.70	102.20
Mar. 30	do	1.35	40.60
Feb. 5	do	1.65	101.00
Feb. 23	do	1.80	110.00
July 6	do	1.15	26.11
Aug. 20	do	1.24	30.78
Oct. 8	do	1.25	32.00
Dec. 5	S. G. Bennett	1.03	14.0
1902.			
May 31	S. G. Bennett	.91	8.3
July 10	do	.84	5.0
Sept. 3	W. B. Clapp	.95	10.0
Nov. 5	S. G. Bennett	.87	5.3

Discharge measurements of Santa Ana River, Alsetrez ditch, in vicinity of Colton and Riverside, San Bernardino and Riverside counties.

Date.	Hydrographer.	Discharge.
1900.		*Sec.-feet.*
Oct. 25	K. Sanborn	1.53
1902.		
Sept. 29	K. Sanborn	1.96

Discharge measurements of Evans lower ditch, Riverside County.

Date.	Hydrographer.	Discharge.
1898.		*Sec.-feet.*
June 19	F. H. Olmsted	5.68
Aug. 28	do	4.87
1899.		
Aug. 30	S. G. Bennett	4.48
1900.		
July 27	S. G. Bennett	5.27
Oct. 25	K. Sanborn	4.36
1902.		
Sept. 29	K. Sanborn	5.35

Discharge measurements of Evans upper ditch, Riverside County.

Date.	Hydrographer.	Dis-charge.
1900.		
July 27	S. G. Bennett	
Oct. 25	K. Sanborn	
1901.		
Aug. 30	J. B. Lippincott	
1902.		
Sept. 29	K. Sanborn	
Sept. 29	....do	

[a] At north line Riverside County. [b] One mile south of north line Riverside County.

Estimated monthly discharge of Santa Ana River at Warm Spring, San Bernardino County, exclusive of Santa Ana canal.

[Drainage area, 188 square miles.]

Month.	Discharge.			Total discharge.	Run-off	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1896.	*Second-feet.*	*Second-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
July	76	48	63	3,891	0.34	0.39
August	83	33	57	3,492	.30	.35
September	77	27	55	3,289	.29	.32
October	170	38	55	3,387	.29	.33
November	52	30	[a]33	1,939	.17	.19
December	40	33	[a]35	2,176	.19	.21
1897.						
January	101	27	62	3,836	0.33	0.37
February	580	72	181	10,060	.96	1.07
March	460	64	119	7,317	.63	.73
April	186	101	146	8,675	.78	.87
May	101	29	61	3,769	.33	.38
June	67	57	63	3,737	.33	.37
July	85	57	67	4,119	.36	.41
August	80	34	57	3,505	.30	.35
September	61	38	47	2,779	.25	.28
October	250	25	42	2,582	.22	.25
November	52	34	[a]38	2,261	.20	.22
December	30	22	[a]26	1,610	.14	.16
The year	580	22	76	54,250	.40	5.39

[a] The reduced flow of November and December is due to closing the Bear Valley dam.

Estimated monthly discharge of Santa Ana River at Warm Spring, San Bernardino County, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1898.	*Second-feet.*	*Second-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
anuary	58	33	40	2,460	0.21	0.24
ebruary	76	33	40	2,221	.21	.22
arch	40	25	32	1,968	.17	.20
pril	34	28	31	1,845	.16	.18
ay	149	26	55	3,382	.29	.33
ne	58	36	44	2,618	.23	.26
ly	53	33	41	2,521	.22	.25
ugust	58	33	41	2,521	.22	.25
ptember	45	28	36	2,142	.19	.21
tober	36	19	26	1,599	.14	.16
ovember	34	18	22	1,309	.12	.13
ecember	28	22	22	1,353	.12	.14
The year	149	18	36	25,939	.19	2.57
1901.						
anuary	600	31	78	4,796	0.41	0.47
ebruary	540	48	194	10,774	1.03	1.07
arch	114	45	68	4,181	.36	.41
pril	107	39	43	2,559	.23	.26
ay	68	35	42	2,582	.22	.25
ne	44	30	37	2,202	.20	.22
ly	42	34	38	2,337	.20	.23
ugust	200	31	50	3,074	.27	.31
ptember	60	42	49	2,916	.26	.29
ctober	96	24	48	2,951	.26	.30
ovember	36	22	26	1,547	.14	.16
ecember	25	21	24	1,476	.13	.15
The year	600	21	58	41,395	.31	4.12

Estimated monthly discharge of Santa Ana canal at Warm Spring, San Bernardino County.

[Drainage area, 188 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	[illegible]
1896.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
July			14	861	0.07	
August			14	861	.07	
September			14	833	.07	
October			16	984	.09	
November			3.5	2,083	.02	
December			4.2	2,582	.02	
1897.						
January	8.5	3.2	5.6	344	0.03	
February	6	0	4	222	.02	
March	6	.5	5.2	320	.03	
April	13	0	3.8	226	.02	
May	20	0	15	922	.08	
June	19	0	16.6	988	.09	
July	18.5	10.6	15.6	960	.08	
August	20	17.4	18.3	1,125	.10	
September			20	1,190	.11	
October			12.4	762	.07	
November			7	417	.04	
December			7	430	.04	
The year			10.9	7,906	.06	
1898.						
January			9	553	0.05	
February			8	444	.04	
March			8	492	.04	
April			8	476	.04	
May			6	369	.03	
June			4	258	.02	
July			2	123	.01	
August			2	123	.01	
September			2	119	.01	
October			0	0	0	
November			0	0	0	
December			0	0	0	
The year			4	2,937	.02	
1901.						
March	6	0	2.71	167	0.01	
April	4.62	0	2.34	139	.01	
May	4.62	3.8	3.96	243	.01	

timated monthly discharge of Santa Ana River and canals at Warm Spring, San Bernardino County.[a]

[Drainage area, 188 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1896.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
ly			77	4,753	0.41	0.47
igust			71	4,353	.38	.44
ptember			69	4,124	.37	.41
tober			71	4,372	.38	.44
ovember			37	2,148	.19	.21
ecember			39	2,435	.21	.24
1897.						
nuary	104	35	68	4,179	0.36	0.41
bruary	585	77	185	10,282	.98	1.02
arch	465	70	124	7,637	.66	.76
pril	190	113	150	8,899	.80	.89
ay	113	48	76	4,690	.41	.47
ne	86	60	80	4,723	.42	.47
ly	102	70	83	5,077	.44	.51
ugust	100	54	75	4,628	.40	.46
ptember	81	58	67	3,968	.35	.39
tober	270	45	54	3,347	.29	.33
ovember	59	40	45	2,678	.24	.27
ecember	38	29	33	2,040	.18	.21
The year	585	29	87	62,148	.46	6.19
1898.						
nuary			49	2,987	0.26	0.30
bruary			48	2,688	.26	.27
arch			40	2,448	.21	.24
pril			39	2,333	.21	.23
ay			61	3,727	.32	.37
ne			48	2,840	.25	.28
ly			43	2,625	.23	.26
ugust			43	2,653	.23	.26
ptember			38	2,223	.20	.22
ctober			26	1,581	.14	.16
ovember			22	1,285	.12	.13
ecember			22	1,364	.12	.14
The year			40	28,754	.21	2.86

[a] Total flow.

Estimated monthly discharge of Santa Ana River and canals at Warm Spr... San Bernardino County—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Dep...
1899.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inch...*
January	34	22	26	1,593	0.14	...
February	34	27	27	1,516	.15	...
March	48	24	32	1,949	.17	...
April	34	22	25	1,458	.13	...
May	27	19	22	1,365	.12	...
June	34	19	22	1,315	.12	...
July	29	19	22	1,371	.12	...
August	19	11	13	782	.07	...
September	12	10	12	690	.06	...
October	19	12	17	1,015	.09	...
November	49	17	21	1,268	.11	...
December	36	18	23	1,427	.12	...
The year	49	10	22	15,749	.12	...
1900.						
January	36	19	23	1,414	0.12	...
February	23	20	22	1,222	.12	...
March	28	20	23	1,414	.12	...
April	43	19	25	1,488	.13	...
May	250	20	57	3,505	.30	...
June	25	19	22	1,309	.12	...
July	25	11	19	1,168	.10	...
August	12	9	11	676	.06	...
September	16	11	12	714	.06	...
October	16	12	14	861	.07	...
November	1,564	14	107	6,367	.57	...
December	31	25	28	1,722	.15	...
The year	1,564	9	30	21,860	.16	...

timated monthly discharge of Santa Ana River and canals at Warm Spring, San Bernardino County—Continued.

Month.	Discharge			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
nuary	600	31	78	4,796	0.41	0.47
ebruary	540	48	194	10,774	1.03	1.07
arch	114	45	68	4,181	.36	.41
pril	107	39	43	2,559	.23	.26
ay	68	35	42	2,582	.22	.25
ne	44	30	37	2,202	.20	.22
ly	42	34	38	2,337	.20	.23
ugust	200	31	50	3,074	.27	.31
ptember	60	42	49	2,916	.26	.29
ctober	96	24	48	2,951	.26	.30
ovember	36	22	26	1,547	.14	.16
ecember	25	21	24	1,476	.13	.15
The year	600	21	58	41,395	.31	4.12
1902.						
nuary	45	20	24	1,476	0.13	0.15
ebruary	240	20	38	2,110	.21	.22
arch	485	41	79	4,858	.43	.50
pril	71	43	51	3,035	.28	.31
ay	45	31	36	2,214	.20	.23
ne	47	23	33	1,964	.18	.20
ly	32	23	26	1,599	.14	.16
ugust	30	22	25	1,537	.14	.16
ptember	29	22	24	1,428	.13	.15
ctober	55	30	40	2,460	.22	.25
ovember	43	19	24	1,428	.13	.15
ecember	27	19	22	1,353	.12	.14
The year	485	19	35	25,462	.19	2.62

Discharge measurements of Santa Ana River at head of Gage canal.[a]

Date.	Hydrographer.	Discharge.
		Sec.-feet.
1888.[b]	W. Irwin	2,000.
1898.		
June 29	J. B. Lippincott	1.
June 30	do	27.
Sept. 21	do	25.

[a] See San Bernardino Valley, Gage canal.
[b] Flood. Since that time floods as great as 4,000 second-feet have been observed.

Discharge measurements of Jurupa Canal.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
1898.		
June 18	F. H. Olmsted	13.
July 1	J. B. Lippincott and K. Sanborn	7.
Aug. 27	F. H. Olmsted	10.
Sept. 22	J. B. Lippincott	5.
May 31	S. G. Bennett	6.
July 15	do	13.
1899.		
Aug. 24	S. G. Bennett	[a]4.
July 26	do	[a]5.
1900.		
July 27	G. S. Bennett	14.
Oct. 19	K. Sanborn	14.

[a] Submerged flume above Colton bridge.

Discharge measurement of Santa Ana River below Jurupa ditch.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
June 17, 1898	F. H. Olmsted	5.

Discharge measurements of Santa Ana River below Roubidoux, Evans Upper and Trujillo ditches.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
July 27, 1900	S. G. Bennett	0.
Oct. 25, 1900	K. Sanborn	

Discharge measurements of Santa Ana River in vicinity of Colton and Riverside, San Bernardino and Riverside Counties.

RIVERSIDE WATER COMPANY'S LOWER CANAL.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
June —, 1898	K. Sanborn	10.27
Sept. —, 1898	do	7.70
Mar. —, 1899	do	16.20
June —, 1899	do	9.09
Aug. —, 1899	do	7.38
Mar. —, 1900	do	8.00
June —, 1900	K. Sanborn	7.16
Sept. —, 1900	do	6.69
June 17, 1898	F. H. Olmsted	9.27
June 18, 1898	do	11.27
		[a] 10.27
July 27, 1900	S. G. Bennett	7.13
Aug. 30, 1901	J. B. Lippincott	[b] 4.52
Sept. 30, 1902	K. Sanborn	3.07

RIVERSIDE WATER COMPANY'S UPPER CANAL.[c]

Aug. 30, 1899	S. G. Bennett	[d] 57.4
July 26, 1900	do	[d] 43.3

ROUBIDOUX DITCH.

June 19, 1898	F. H. Olmsted	8.94
Aug. 28, 1898	do	8.50
July 27, 1900	S. G. Bennett	8.18
Oct. 25, 1900	K. Sanborn	7.80
Aug. 30, 1901	J. B. Lippincott	8.75
Sept. 30, 1902	K. Sanborn	7.19

SANTA ANA RIVER 1¼ MILES BELOW INTAKE OF RIVERSIDE WATER COMPANY'S LOWER CANAL.

Aug. 27, 1898	F. H. Olmsted	0.50

[a] Mean for June 17 and 18.
[b] One-fourth of a mile below headworks; 0.4 second-feet wasted below point of measurement into river for Roubidoux Canal.
[c] See also Riverside Water Company's upper canal, under San Bernardino Valley.
[d] In flume above tunnel near Riverside Mesa.

Discharge measurements of Santa Ana River in vicinity of Colton and Riverside, etc.—Continued.

SPRING BROOK BELOW WEST RIVERSIDE BRIDGE.

Date.	Hydrographer.	Discharge.
		Sec.-ft.
June 19, 1898	F. H. Olmsted	2.92
Aug. 28, 1898	....do	1.57
July 28, 1900	S. G. Bennett	2.77
Aug. 30, 1901	J. B. Lippincott	2.46
Aug. 28, 1898	F. H. Olmsted	[illegible]
Oct. 25, 1900	K. Sanborn	[illegible]

SANTA ANA RIVER BELOW WEST RIVERSIDE BRIDGE.

July 30, 1900	S. G. Bennett	1.16
Aug. 30, 1901	J. B. Lippincott	1.19

SANTA ANA RIVER AT GALLIGERS FORD, 2 MILES BELOW WEST RIVERSIDE BRIDGE.

Aug. 30, 1899	S. G. Bennett	5.6

[a] Santa Ana River, West Riverside Bridge.

Discharge measurements of Trujillo ditch, tributary to Santa Ana.

Date.	Hydrographer	Discharge.
		Sec.-ft.
July 27, 1900	S. G. Bennett	0.46
Oct. 25, 1900	K. Sanborn	[illegible]

Discharge measurement of Santa Ana River 1,000 feet below Roubidoux ditch intake.

Date.	Hydrographer.	Discharge.
		Sec.-ft.
Oct. 25, 1900	K. Sanborn	0.76

Discharge measurements of Santa Ana River in vicinity of Rincon, Riverside County.

ANAHEIM UNION CANAL.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
June 22, 1898	F. H. Olmsted	34.74	5 miles below division box.
Sept. 15, 1899	J. B. Lippincott	27.92	
Oct. 26, 1899	do	17.14	1 mile below Esperanza.
Aug. 15, 1900	W. P. Searcy	18.37	
Sept. 3, 1900	do	18.22	
Aug. 31, 1901	do	23.11	

SANTA ANA RIVER AT AUBURNDALE BRIDGE.

July 17, 1888	F. C. Finkle	14.6	
Aug. 22, 1888	do	13.8	
Sept. 15, 1888	do	14.2	
Aug. 14, 1889	do	15.6	
Sept. 28, 1889	do	16.7	
Aug. 13, 1890	do	22.3	
Sept. 10, 1891	do	25.6	
Sept. 11, 1892	do	43.4	
June 21, 1898	F. H. Olmsted	60.00	Including ditches.
Aug. 30, 1899	S. G. Bennett	53.10	Do.
Sept. 12, 1899	J. B. Lippincott	59.83	
July 28, 1900	S. G. Bennett	54.45	Do.
Oct. 5, 1900	W. W. Cockins, jr	69.70	Do.
Aug. 27, 1901	J. B. Lippincott	43.70	Above Roberts ditch.
Aug. 31, 1901	do	28.54	Do.

CASTILLO DITCH BELOW RIVERSIDE NARROWS.

Aug. 30, 1901	J. B. Lippincott	1.19	

CHINO CREEK NEAR RINCON.

Aug. 30, 1898	F. H. Olmsted	4.95	
May 2, 1899	F. Rolfe	12.79	
May 15, 1899	do	8.64	
June 3, 1899	do	17.02	
June 15, 1899	do	5.63	
July 4, 1899	do	3.02	
July 17, 1899	do	4.68	

Discharge measurements of Santa Ana River in vicinity of Rincon, etc.—Cont'd.

CHINO CREEK NEAR RINCON—continued.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
Aug. 1, 1899	F. Rolfe	7.49	
Aug. 15, 1899	do	2.14	
Aug. 31, 1899	do	3.19	
Sept. 13, 1899	J. B. Lippincott	3.53	
Oct. 25, 1899	do	14.52	
Apr. 17, 1900	W. P. Searcy	8.79	
June 24, 1900	do	3.97	
July 7, 1900	do	2.09	
July 28, 1900	S. G. Bennett	2.20	
Aug. 15, 1900	W. P. Searcy	1.08	
Sept. 3, 1900	do	0.0	
Oct. 5, 1900	W. W. Cockins, jr	5.00	
Aug. 31, 1901	J. B. Lippincott	2.80	

DIVISION BOX SANTA ANA AND ANAHEIM CANALS.

June 22, 1898	F. H. Olmsted	67.5	
Aug. 30, 1898	do	52.9	
Aug. 30, 1899	S. G. Bennett	59.6	
Sept. 15, 1899	J. B. Lippincott	71.7	
Oct. 25, 1899	do	144.7	
July 28, 1900	S. G. Bennett	49.7	
Oct. 5, 1900	W. W. Cockins, jr	75.1	
Aug. 27, 1901	J. B. Lippincott	64.5	
Aug. 31, 1901	do	55.4	

DURKEE DITCH.

Sept. 3, 1899	J. B. Lippincott	1.38	Near ranch house.
Sept. 13, 1899	do	6.14	Newberry east line.
July 28, 1900	S. G. Bennett	1.80	At ranch house.
Aug. 27, 1901	J. B. Lippincott	3.98	
Aug. 31, 1901	do	8.24	

SANTA ANA RIVER, OPPOSITE ESPERANZA STATION.

Oct. 26, 1899	J. B. Lippincott	49.2	

ischarge measurements of Santa Ana River in vicinity of Rincon, etc.—Cont'd.

FULLER DITCH.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
nly 28, 1900		13.00	Said by Fuller to be carrying this amount at intake.
ct. 5, 1900	W. W. Cockins, jr	6.50	
ug. 30, 1901	J. B. Lippincott	9.69	Near intake.
Do	do	7.15	At Fuller's ranch house.

SANTA ANA RIVER, ABOVE FULLER'S DITCH.

ug. 30, 1901	J. B. Lippincott	24.84	Intake.

GILLILAND'S DITCH, AUBURNDALE BRIDGE.

uly 28, 1900	S. G. Bennett	1.40	

Discharge measurement of Santa Ana River, Newberry's east line.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
ug. 31, 1901	J. B. Lippincott	40.7	

Discharge measurements of Newberry ditch.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
July 28, 1900	S. G. Bennett	5.47	At Auburndale bridge.
Aug. 27, 1901	J. B. Lippincott	3.05	At head.
Aug. 31, 1901	do	3.23	Do.

Discharge measurement of Newton ditch, below Narrows.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
Aug. 30, 1901	J. B. Lippincott	7.04	

Discharge measurements of Santa Ana River 1 mile below railroad bridge, Rincon, Cal.

Date.	Hydrographer.	Discharge.	Remarks.
1898.		*Sec.-feet.*	
June 21	F. H. Olmsted	[a]79.81	
Do	do	[b]3.18	
	Total	82.99	
Aug. 29	F. H. Olmsted	[a]62.67	
Do	do	[b]4.15	
	Total	66.82	
1899.			
Jan. 3	S. G. Bennett	[a]209.4	
Do	do	[b]2.3	
	Total	211.7	
Jan. 16	F. Rolfe	231.9	
Jan. 28	do	[a]216.0	
Do	do	[b]6.5	
	Total	222.5	
Feb. 15	F. Rolfe	[a]181.0	
Do	do	[c]1.75	
	Total	182.75	
Mar. 4	F. Rolfe ..... total	108.6	
Mar. 18	do ..... do	199.89	
Apr. 6	do	172.23	
	Total	480.72	
April 18	F. Rolfe	[a]101.10	One mile below railroad bridge.
Do	do	[b]2.75	
	Total	103.85	
May 2	F. Rolfe	[a]100.34	
Do	do	[b]2.45	
	Total	102.79	
May 15	F. Rolfe	[a]100.36	
Do	do	[b]3.95	
	Total	104.31	

[a] River. [b] Ditch. [c] Canal.

Discharge measurements of Santa Ana River, etc.—Continued.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
ıne 3	F. Rolfe	[a]110.27	
Do	do	[b]3.18	
	Total	113.45	
ıne 15	F. Rolfe	[a]84.43	
Do	do	[b]1.94	
	Total	86.37	
ıly 4	F. Rolfe	[a]68.89	
Do	do	[b]2.42	
	Total	71.31	
ıly 16	S. G. Bennett and F. Rolfe.	[a]101.41	
Do	do	[b]1.89	
	Total	103.30	
Do	S. G. Bennett and F. Rolfe.	[a]87.89	
Do	do	[b]1.65	
	Total	89.54	
ıly 18	F. Rolfe	[a]64.13	One mile below railroad bridge.
Do	do	[b]1.54	
	Total	65.67	
ug. 1	F. Rolfe	[a]57.82	
Do	do	[b]3.44	
	Total	61.26	
ug. 15	F. Rolfe	[a]64.71	
Do	do	[b]3.16	
	Total	67.87	
ug. 30	F. Rolfe	[a]65.90	
Do	do	[b]2.00	
	Total	67.90	
ug. 31	F. Rolfe	[a]68.02	Do.
Do	do	[b]3.06	
	Total	71.08	
ept. 13, 1900.	J. B. Lippincott	[a]72.73	Do.
pr. 16	S. G. Bennett	90.86	Do.

[a] River. [b] Ditch.

Discharge measurements of Santa Ana River at Rincon wagon bridge.

Date.	Hydrographer.	Discharge
1899.		Sec.-ft.
Sept. 13	J. B. Lippincott	2
Oct. 25	do	14
Oct. 26	do	14
Dec. 28	do	16
1900.		
Apr. 17	W. P. Searcy	10
June 24	do	69
July 7	do	84
July 28	S. G. Bennett	9
Aug. 15	W. P. Searcy	8
Sept. 3	do	8
Oct. 5	W. W. Cockins, jr	7
1901.		
Aug. 27	J. B. Lippincott	7
Aug. 31	do	6
1902.		
Sept. 2	W. B. Clapp	7

Discharge measurements of Santa Ana River at Riverside Narrows.

Date.	Hydrographer.	Discharge
1888.		Sec.-ft.
July 16	F. C. Finkle	1
July 17	do	3
Aug. 21	do	4
Sept. 14	do	5
1889.		
Aug. 13	do	1
Sept. 27	do	1
1890.		
Aug. 12	do	1
1901.		
Sept. 9	do	1
1892.		
Sept. 10	do	2

charge measurements of Santa Ana River at Riverside Narrows—Continued.

Date.	Hydrographer.	Discharge.
898.		*Sec.-feet.*
ne 20	F. H. Olmsted	47.63
g. 29	do	39.05
899.		
y 17	F. Rolfe	31.70
t. 9	J. B. Lippincott	39.69
900.		
y 27	S. G. Bennett	38.41
. 25	K. Sanborne	70.64
901.		
g. 30	J. B. Lippincott	38.87
902.		
. 10	K. Sanborne	43.25

charge measurements of canals and ditches of Santa Ana River system near Rincon, Riverside County.

DITCH ON RIGHT BANK OF SANTA ANA RIVER 3 MILES BELOW RIVERSIDE NARROWS.

Date.	Hydrographer.	Discharge.
898.		*Sec.-feet.*
ne 20	F. H. Olmsted	3.75

CH ON RIGHT BANK OF SANTA ANA RIVER 5 MILES BELOW RIVERSIDE NARROWS, ON GRIFFITH'S PLACE.

ne 20	F. H. Olmsted	9.99

ROBERTS DITCH.

1901.		
ig. 27	J. B. Lippincott	0
ig. 31	do	0

Discharge measurements of canals and ditches, etc.—Continued.

SANTA ANA VALLEY IRRIGATION COMPANY'S CANAL, ORANGE COUNTY, CAL.

Date.	Hydrographer.	Discharge
1898.		
June 22	F. H. Olmsted	[illegible]
Aug. 30	do	[illegible]
1899.		
May 26	F. Rolfe	[illegible]
Sept. 15	J. B. Lippincott	[illegible]
Oct. 26	do	[illegible]
1900.		
Sept. 3	W. P. Searcy	[illegible]
Aug. 15	do	[illegible]
1901.		
Aug. 31	J. B. Lippincott	[illegible]

BEECHER DITCH, AT RINCON BRIDGE.

1901.		
June 24	W. P. Searcy	[illegible]

TOWNSEND DITCH.

1898.		
June 20	F. H. Olmsted	[illegible]
1900.		
Oct. 5	W. W. Cockins, jr	[illegible]

WILBUR DITCH.

1901.		
Aug. 30	J. B. Lippincott	[illegible]

YORBA DITCH.

1899.		
Oct. 26	J. B. Lippincott	[illegible]
1900.		
Aug. 15	W. P. Searcy	[illegible]
Sept. 3	do	[illegible]
1901.		
Aug. 31	J. B. Lippincott	[illegible]

[a] Near bridge to Yorba.
[b] Three miles above Olive
[c] First road crossing.
[d] At road crossing at head of cement lining
[e] Estimated above drop from Anaheim ditch and opposite Esperanza.

scellaneous low-water measurements made in watershed of Santa Ana River, Los Angeles, San Bernardino, Riverside, and Orange counties.

Date.	Locality.	Area of section.	Mean velocity.	Discharge.
900.		*Sq. feet.*	*Feet per sec.*	*Sec.-feet.*
pt. 25	Frey's ranch, near Spadra	0.80	2.312	1.85
Do	Phillips's ranch, near Spadra (weir)			.74
pt. 27	C. L. Lancaster, Mesa avenue, Lordsburg (weir)			.559
pt. 26	Covina Irrigation Co. compressor pumping plant, south of Lordsburg			3.58
pt. 24	Neuruff place, corner Holt avenue and San Antonio avenue, Pomona (weir)			.33
pt. 26	Pomona Land and Water Co., Garey avenue (weir)			1.28
pt. 26	Consolidated Water Co.'s Pomona air-compressor plant (weir)			3.34
pt. 24	Consolidated Water Co., north of Pomona College (weir)			.82
pt. 25	James Warden's place (weir)			.25
pt. 24	Brundege place, San Antonio avenue, Pomona	.25	1.04	.26
pt. 25	Del Monte Water Co. (weir)			.96
Do	San Antonio Water Co.'s wells in Claremont; water goes to Ontario (weir)			.40
Do	San Antonio Water Co.'s wells at Indian Hill, ¼ mile north of Pomona College (weir)			.99
Do	San Antonio Canyon. From records of Pomona Land and Water Co. The discharge from San Antonio Canyon was 7.53 second-feet Sept. 2, 1895, and 9.02 second-feet on Sept. 6, 1897 (weir).[a]			3.72
	RED HILL, CUCAMONGA.			
ly 11	Cucamonga Land and Water Co., Cucamonga Creek, 30-inch pipe line (weir)			1.15
Do	Cucamonga Land and Water Co., Lone Star Spring pumping plant (weir)			1.20
Do	Cucamonga Land and Water Co., "Y" tunnel (weir)			1.68
Do	Stowell water from 90-acre tract; west side part to Ontario (weir)			2.97
Do	San Antonio Water Co., Haskell well (weir)			2.13
Do	San Antonio Water Co., Sixteenth street, pumping plant (weir)			1.72
	Total			10.85

[a] July 11, 1900, measurement made of water in San Antonio Canyon by S. G. Bennett; discharge, second-feet.

Miscellaneous low-water measurements made, etc.—Continued.

Date.	Locality.	Area of section.	Mean velocity.	Discharge.
1900.	RED HILL, CUCAMONGA—continued.			
July 11	Natural surface flow of Cucamonga Creek in canyon (Iomosa Water Co.)	*Sq. feet.* 0.22	*Feet per sec.* 4.10	
	Developed by bed-rock tunnel			
	Total			
Aug. 4	Cucamonga Land and Water Co., Lone Star Spring pumping plant (weir)			
June 8	Lytle Creek at intake of Rialto Canal (weir)			
Sept. 29	....do			
June 8	Cajon Creek Canyon in flume, opposite Keenbrook station	1.49	.92	
July 12	West Twin Creek in flume	.084	2.66	
Oct. 1	....do			
July 12	East Twin Creek, Del Rosa cement canal	.40	1.55	
Oct. 1	....do			
July 12	East Twin Creek, Kansas City Syndicate development	.44	3.45	
Oct. 1	....do			
July 12	City Creek measurement in cement canal	.32	.50	
Oct. 1	City Creek, at head of pipe line	.24	.88	
July 12	Plunge Creek at intake of ditch (weir)			
July 13	Below wasteway of Santa Ana Canal	9.29	2.404	
Do	South Fork or Redlands Canal, water not going over weir into North Fork or Highlands Canal on account of repairs (weir)			
Do	Redlands tunnel (weir)			
Do	Morton Canyon (weir)			
Oct. 2	South Fork or Redlands Canal (weir)			
Do	North Fork or Highlands Canal (weir)			
Do	Green Spot pipe line (weir)			
Do	Redlands tunnel (weir)			
Do	Morton Canyon (weir)			
July 13	Water in Mill Creek zanja (weir)			
Do	Mill Creek. Water is being pumped by Crafton Water Co. et al. in Mill Creek Canyon and Yucipe Valley (weir)			
	Total			

Miscellaneous low-water measurements made, etc.—Continued.

Date.	Locality.	Area of section.	Mean velocity.	Discharge.
1900.	RED HILL, CUCAMONGA—continued.			
ct. 2	Crafton Water Co.'s pumping plant, Mill Creek Canyon (weir)	*Sq. feet.*	*Feet per sec.*	*Sec.-feet.* 1.35
Do	At mouth of Mill Creek Canyon (weir)			7.21
	Total			8.56
ıly 14	San Timoteo Canyon ditch at Bicknell Station	1.00	1.50	1.50
ıne —	Haws & Talmadge			.00
ıne —	Rabel ditch			.35
ıne —	Shay ditch			.40
ıne —	McKenzie ditch			1.57
ıne —	Meeks & Daley ditch			13.78
ıne —	Beams ditch			.50
ıne —	Riverside Water Co., upper canal			52.94
ıne —	Riverside Water Co., lower canal			7.16
ıne —	Timber ditch			.00
ıne —	Gage Canal, Santa Ana River			.29
ıne —	Gage Canal, Palm avenue			22.52
ıne —	Logsdon & Farrel ditch			.49
ıne —	Whitlock ditch			.00
ıne —	Daley ditch			1.12
ıne —	McIntyre ditch			.01
ıne —	Whiting ditch			.13
ıne —	Swamp ditch			.89
ıne —	Ranchero ditch			.55
ıne —	Ward & Warren ditch			1.70
ıne —	Mill flume, Riverside Water Co			2.17
ıne —	Mill pump, Riverside Water Co			1.88
ıne —	Camp Carlton ditch			2.60
ıne —	East Riverside ditch			5.38
ıne —	Colton Terrace Water Co			1.54
ıne —	City of Colton			3.21
ıne —	Bloomington flume			3.68
ıly 26	Riverside Water Co.'s upper canal in flume 150 feet above tunnel Riverside Mesa	17.48	2.477	43.30
ıly 27	North Riverside and Jurupa Canal in flume near Beckstead's house	6.94	2.077	14.42
ıly 27	Riverside Water Co.'s lower canal	3.35	2.128	7.13
ıly 27	Roubidoux ditch	6.21	1.317	8.18
ıly 27	Trujillo ditch	.75	.61	.46

Miscellaneous low-water measurements made, etc.—Continued.

Date.	Locality.	Area of section.	Mean velocity.	Discharge
1900.	RED HILL, CUCAMONGA—continued.	*Sq. feet.*	*Feet per sec.*	*Sec. ft.*
July 27	75 feet below intake of Trujillo ditch	0.38	1.17	0.44
July 27	Evans upper ditch	.95	1.10	1.04
	Total flow Santa Ana at Roubidoux ditch intake			10.2
July 27	Alsetrez ditch from Spring Brook, 100 feet below West Riverside bridge	1.95	1.42	2.77
July 27	200 feet below West Riverside bridge	1.77	.65	1.16
July 27	West Riverside bridge, Roubidoux Mountain	2.85	1.85	5.27
July 27	At Riverside Narrows	26.54	1.443	38.3
Sept. 13	Riverside Water Co.'s lower canal	3.36	1.99	6.6
Oct. 19	North Riverside and Jurupa canal	6.69	2.10	14.0
Oct. 25	Roubidoux ditch	5.95	1.31	7.8
Oct. 25	Trujillo ditch	1.10	.48	.5
Oct. 25	20 feet below intake of Trujillo ditch	.80	.70	.5
Oct. 25	Evans's upper ditch	2.42	1.37	3.3
	Total			12.3
Oct. 25	Alsetrez ditch from Spring Brook, West Riverside bridge	1.75	.87	1.5
Oct. 25	At West Riverside bridge	5.50	1.54	8.45
Oct. 25	Evans's ditch, West Riverside bridge	2.52	1.75	4.4
Oct. 25	At Riverside Narrows	43.3	1.63	70.6
July 28	300 feet above Auburndale bridge	28.65	1.576	45.1
July 28	Newberry ditch, Auburndale bridge	5.32	1.03	5.4
July 28	Ditch south of Newberry ditch, Auburndale bridge	1.58	1.47	2.3
July 28	Gilliland ditch, Auburndale bridge	1.49	.94	1.4
	Total			54.5
Oct. 5	Auburndale bridge	40.50	1.577	63.9
Oct. 5	Townsend ditch, Auburndale bridge	6.10	.957	5.8
Oct. 5	Fuller's ditch, near schoolhouse	5.10	1.274	6.5
July 28	Rincon bridge	35.55	1.704	60.6
July 28	Chino Creek under bridge, Chino-Corona road	3.66	.60	2.2
Oct. 5	Rincon bridge	43.90	1.69	74.2
Oct. 5	Chino Creek	1.90	2.63	5.0
July 28	Durkee ditch, near ranch house	1.40	1.30	1.8
July 28	At Anaheim and Santa Ana division box	23.64	2.103	49.7
Oct. 5	....do	29.00	2.59	75

For tabulation of a large number of water measurements in the San Bernardino Valley and Riverside Narrows and in the basin of the Santa Ana River, see San Bernardino Valley

SANTA ANA RIVER, MILL CREEK.

See Mill Creek (page 158).

SANTA ANA RIVER, LYTLE CREEK.

See Lytle Creek (page 139).

SANTA ANA RIVER, SAN ROQUE CREEK.

See Arroyo Burro (page 43).

SANTA BARBARA COUNTY.

Miscellaneous measurements of streams east of Santa Barbara City, Santa Barbara County, made in July and August, 1889, by George F. Wright.

Stream.	Discharge.	Area of watershed.
	Sec.-feet.	*Sq. miles.*
Rincon	0.12	10.5
Gubernador	.58	4.2
Carpenteria	.08	44.0
Santa Monica	.23	4.3
Padaro	.31	2.2
Dinsmore	.23	2.2
Cold Stream	.23	3.0
Mission	.46	4.0

Miscellaneous measurements of streams west of Santa Barbara City, Santa Barbara County, made in July and August, 1889, by George F. Wright.

Stream.	Discharge.	Area of watershed.
	Sec.-feet.	*Sq. miles.*
Arroyo Burro	0.23	2.5
Maria Ignacia	.23	16.5
San Jose	.27	.....
San Pedro	.08	3.0
Arroyo Carnero	.08	1.0
Arinas	.08	1.0
Tecolote	.27	2.0
Aguilar	.12	2.0
Dos Pueblos	.54	3.25
Canyada Verde	.08	2.00
Canyada Llaces	.08	1.50
El Capitan	.23	1.50
Canyada del Corral	.15	1.00
Canyada Refugio	.31	2.00

Discharge measurements of San Pedro Creek, Santa Barbara County, Cal.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
Aug. —, 1889	G. F. Wright	0.08	Drainage area, 3 square miles.

Discharge measurements of San Timoteo Creek, Riverside County.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
July 14, 1900	S. G. Bennett	1.50	Bicknel station.

Discharge measurements of San Ysidro Creek, Santa Barbara County, Cal., above dam.

Date.	Hydrographer.	Discharge	Remarks.
		Sec.-feet.	
Nov. 2, 1899	Greenheld	0.06	
Dec. 3, 1899	do	.15	
Mar. 6, 1900	do	1.00	
Mar. 19, 1900	do	.35	
June 16, 1900	R. Moyer	.07	

SANTA CLARA RIVER.

Discharge measurements of Santa Clara River at point below mouth of San Francisquito Creek, on Newhall ranch, Los Angeles County.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
Aug. 9, 1898	F. H. Olmsted	10.83	
Aug. 19, 1899	S. G. Bennett	3.38	East channel.
Aug. 19, 1899	do	1.65	West channel.
Aug. 19, 1899	do	3.37	Newhall ditch.
	Total	8.40	
Oct. 8, 1900	W. W. Cockins, jr	3.64	East channel.
Oct. 8, 1900	do	3.25	West channel.
Oct. 8, 1900	do	3.35	Newhall ditch.
	Total	10.24	

ischarge measurements of Santa Clara River at point 2 miles east of Camulos, Ventura County.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
ıne 18, 1898	J. B. Lippincott	25.74	
ug. 11, 1898	F. H. Olmsted	17.36	
ıg. 19, 1899	S. G. Bennett	17.63	Camulos ditch.
ug. 19, 1899	do	1.24	River.
	Total	18.87	
:t. 8, 1900	W. W. Cockins, jr	11.38	Camulos ditch at head of wooden flume.

ischarge measurements of Santa Clara River in Cienega, 1 mile east of Fillmore, Ventura County.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
ar. 15, 1899	S. G. Bennett	3.60	

Discharge measurements of Santa Clara River near Santa Paula, Ventura County.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
ug. 18, 1899	S. G. Bennett	16.00	Farmers ditch.
ug. 18, 1899	do	8.60	Grease or Santa Clara ditch.
ug. 18, 1899	do	5.80	Ditch taken out on east side of river.
ug. 18, 1899	do	10.30	River.
	Total	40.70	

SANTA MONICA CREEK.

Discharge measurements of Santa Monica Creek, Santa Barbara County.

[Drainage, 4.3 square miles.]

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
ug. —, 1889	G. F. Wright	0.23	¼ mile above Fithian's house.
ıne 16, 1900	R. Moyer	.11	

SANTA PAULA RIVER.

Discharge measurement of Santa Paula River above Neeper schoolhouse, near Santa Paula, Ventura County, Cal.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. 18, 1899	S. G. Bennett	0.85	

SANTA YNEZ RIVER.

As determined from Geological Survey maps the area of the drainage basin of this stream above Juncal dam site is 13.4 square miles. E. J. S. Purslow stated in a report to the Santa Barbara Water Company in 1896 that the Santa Ynez River at the Juncal reservoir site was measured during the "past winter and spring;" further details are not given. The discharge stated was 800,000,000 gallons=2,455 acre-feet. The rainfall for season at Santa Barbara was 13.77 inches and the mean from 1867 to date is 16.82 inches. The period of stream observations probably extended from November 1, 1895, to July 1, 1896. This includes Alder Creek water below Juncal.

During the winter of 1902–3 the city of Santa Barbara cooperated with the United States Geological Survey in determining the run-off from portions of the drainage basin of the Santa Ynez River, as given below.

Measurements were first made of the main Santa Ynez River above its junction with the Mono tributary. The drainage area above this point is 71 square miles. Measurements were also made of the discharge of the Mono tributary of the Santa Ynez River at its mouth. The drainage area above this point is 119 square miles. Both of these streams flow from the mountains of the Coast Range, the elevations of their basins ranging from 1,400 to 7,000 feet.

The estimated average rainfall in these drainage basins is 22 inches and during the season of 1902–3 the mean rainfall was probably exceeded by about 2 inches. The precipitation, however, occurred in gentle slow storms until the latter part of March, when there were heavier rains. It is locally stated that the stream flow is not up to the average. This probably could be explained by the fact of the gentle rains referred to above, and to the further fact that the season 1902–3 was preceded by years of protracted drought.

t of discharge measurements of Santa Ynez River above junction with Mono.

Date.	Hydrographer.	Gage height.	Discharge.
903.		*Feet.*	*Sec.-feet.*
ı. 12	Howard Rankin	1.10	1.79
ı. 25	do	1.10	1.93
ı. 27	do	1.20	3.30
ı. 28	do	3.55	457.24
ı. 29	do	1.70	49.75
ı. 30	do	1.50	22.45
ı. 31	do	1.48	17.90
b. 1	do	1.50	22.18
b. 2	do	1.45	16.01
b. 3	do	1.42	14.61
b. 4	do	1.45	15.31
b. 5	do	1.45	14.92
b. 7	do	1.45	15.63
b. 8	do	1.58	24.74
b. 9	do	1.50	18.38
b. 10	do	1.49	17.63
b. 11	do	1.46	16.15
b. 12	do	1.45	15.54
b. 13	do	1.44	14.92
b. 14	do	1.44	14.72
b. 16	do	1.40	10.85
b. 17	do	1.40	11.34
b. 18	do	1.40	11.11
b. 19	do	1.40	11.05
b. 20	do	1.39	10.75
b. 21	do	1.39	10.98
b. 23	do	1.38	10.11
b. 24	do	1.37	9.05
b. 25	do	1.37	9.07
b. 26	do	1.36	8.58
b. 27	do	1.35	8.72
b. 28	do	1.35	8.32
ar. 1	do	1.35	8.16
ar. 2	do	1.35	8.01
ar. 3	do	1.35	7.91
ar. 4	do	1.45	14.78
ar. 5	do	1.65	31.60
ar. 6	do	1.50	20.19
ar. 7	do	1.50	19.95
ar. 9	do	1.43	13.52
ar. 10	do	1.42	13.20
ar. 11	do	1.42	13.42

List of discharge measurements of Santa Ynez River, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge
1908.		*Feet.*	*Sec.-ft.*
Mar. 12	Howard Rankin	1.41	12.7
Mar. 13	do	1.42	13.4
Mar. 14	do	1.43	13.8
Mar. 15	do	1.43	13.1
Mar. 16	do	1.43	13.8
Mar. 17	do	1.42	11.6
Mar. 18	do	1.41	11.2
Mar. 19	do	1.40	11.0
Mar. 20	do	1.40	10.8
Mar. 21	do	1.40	10.5
Mar. 22	do	1.40	10.8
Mar. 23	do	1.40	10.6
Mar. 25	do	1.67	29.9
Mar. 26	do	1.55	19.9
Mar. 27	do	1.50	17.1
Mar. 28	do	1.49	16.6
Mar. 29	do	1.50	17.1

List of discharge measurements of Mono Creek at mouth.

Date.	Hydrographer.	Gage height.	Discharge
1903.		*Feet.*	*Sec.-ft.*
Jan. 28	Howard Rankin	2.95	295.0
Jan. 29	do	1.55	20.2
Jan. 30	do	1.30	12.7
Jan. 31	do	1.25	9.8
Feb. 1	do	1.35	14.8
Feb. 2	do	1.30	10.2
Feb. 3	do	1.20	6.8
Feb. 4	do	1.28	8.8
Feb. 5	do	1.28	8.2
Feb. 6	do	1.21	8.0
Feb. 8	do	1.35	11.8
Feb. 9	do	1.29	8.8
Feb. 10	do	1.28	8.6
Feb. 11	do	1.27	8.7
Feb. 12	do	1.26	8.6
Feb. 13	do	1.25	7.8
Feb. 14	do	1.20	4.7
Feb. 16	do	1.20	5.2
Feb. 17	do	1.20	5.0

List of discharge measurements of Mono Creek at mouth—Continued.

ate.	Hydrographer.	Gage height.	Discharge.
03.		*Feet.*	*Sec.-feet.*
. 18	Howard Rankin	1.20	5.14
. 19	do	1.20	5.17
. 20	do	1.19	4.75
. 21	do	1.19	4.74
. 23	do	1.17	4.65
. 24	do	1.15	4.60
. 25	do	1.15	4.56
. 26	do	1.15	4.45
. 27	do	1.14	3.79
. 28	do	1.14	3.81
r. 1	do	1.12	3.61
r. 2	do	1.12	3.62
r. 3	do	1.12	3.64
r. 4	do	1.80	10.99
r. 5	do	1.60	25.85
r. 6	do	1.37	13.57
r. 7	do	1.35	13.28
r. 9	do	1.80	9.77
r. 10	do	1.25	6.58
r. 11	do	1.22	6.32
r. 12	do	1.22	6.56
r. 13	do	1.22	6.49
r. 14	do	1.27	9.22
r. 15	do	1.25	7.52
r. 16	do	1.30	9.83
r. 17	do	1.32	9.94
r. 18	do	1.26	8.19
r. 19	do	1.25	7.99
r. 20	do	1.24	7.08
r. 21	do	1.24	7.07
r. 22	do	1.23	7.18
r. 23	do	1.23	7.17
r. 25	do	2.50	153.23
r. 26	do	1.90	62.52
r. 27	do	1.70	36.27
r. 28	do	1.60	26.63
r. 29	do	1.61	29.54
r. 30	do	2.65	177.46
r. 31	do	2.80	227.31
pr. 1	do	4.50	710.58
pr. 2	do	3.00	269.83

SAWPIT CREEK.

Discharge measurement of Sawpit Creek at Division Box, Los Angeles County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
July 1, 1898	F. H. Olmsted	1.33	Near mouth of canyon.

SESPE CREEK.

Discharge measurements of Sespe Creek, Santa Clara River, Ventura County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. 11, 1898	F. H. Olmsted	2.5	
Mar. 15, 1899	S. G. Bennett	8.3	At head of Sespe Land & Water Co. Canal.
Aug. 18, 1899	....do	1.9	Do.

SHASTA RIVER.

Discharge measurement of Shasta River.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Aug. —, 1899	M. M. O'Shaughnessy	279	Wagon bridge 1 mile south of Montague railroad station

SNOW CREEK.

Discharge measurement of Snow Creek, Palm Valley, Riverside County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Feb. 22, 1898	J. B. Lippincott	4.5	

SPRING VALLEY WATER COMPANY.

See San Mateo Creek, Water Supply and Irrigation Paper No. , page 390.

STANISLAUS RIVER.

The river has its source on the western slope of the Sierra Nevada n California. It drains a country lying between the basins of Moke-umne River on the north and Tuolumne River on the south, and flows n a general southwesterly direction, entering San Joaquin River 23 iiles above Stockton. A number of canals divert water from this tream on either side, the principal one being the canal of the Stan-slaus and San Joaquin Water Company, which irrigates lands in the icinity of Oakdale and between Knights Ferry and Stockton.

The canal of the Stanislaus and San Joaquin Water Company iverts water from Stanislaus River at a point 3 miles above Knights 'erry, or approximately 15 miles above Oakdale. The volume of his canal at what is known as section 3, was rated on June 1, 1898, y turning in various amounts of water and measuring the same with meter. It was found on June 6, 1899, that silt had accumulated in he bottom of the flume at the old gage, and a new station was dopted. This point was rated similarly to the one of the year pre-ious.

The record at this station was discontinued February 16, 1901.

Discharge measurements of Stanislaus River at Oakdale, Stanislaus County.

Date.	Hydrographer.	Gage height.	Dis-charge.
1895.		*Feet.*	*Sec.-feet.*
lay 3	J. B. Lippincott	8.85	7,744
uly 1	do	6.17	3,754
ug. 28	do	2.40	279
ct. 10	do	2.11	192
ov. 29	do	2.12	147
1896.			
pr. 17	J. A. Vogleson	5.40	2,801
uly 5	C. C. Babb	4.80	2,061
ept. 7	H. Crowe	2.50	304
ct. 29	J. B. Lippincott	2.40	210
1897.			
eb. 16	J. B. Lippincott	4.22	1,346
une 30	J. B. Lippincott and B. Cole	8.60	6,754
uly 14	A. Q. Campbell	3.20	1,015
ept. 5	do	2.00	144
ct. 29	do	2.40	223
ec. 19	J. B. Lippincott	3.00	429

Discharge measurements of Stanislaus River at Oakdale, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge
1898.		*Feet.*	*Sec.-feet*
Apr. 17	J. B. Lippincott	5.30	2,3[illegible]
June 2	do	3.77	9[illegible]
July 29	do	[a]4.30	[illegible]
Oct. 6	do	4.20	[illegible]
Dec. 22	do	4.97	3[illegible]
1899.			
Mar. 3	J. B. Lippincott	5.13	[illegible]
Apr. 20	S. G. Bennett	8.80	3,8[illegible]
May 18	do	7.63	2,6[illegible]
June 5	do	7.94	3,0[illegible]
June 8	do	8.42	3,5[illegible]
June 28	do	6.3	1,1[illegible]
Aug. 3	do	4.53	1[illegible]
Sept. 9	do	4.41	[illegible]
Dec. 6	J. B. Lippincott	5.41	5[illegible]
1900.			
Apr. 5	S. G. Bennett	6.82	1,7[illegible]
May 19	do	9.33	4,5[illegible]
June 21	do	6.65	1,4[illegible]
Aug. 11	do	4.38	[illegible]
Sept. 6	do	4.25	[illegible]
Dec. 28	do	5.66	6[illegible]
1901.			
Jan. 29	S. G. Bennett	6.18	[illegible]
Oct. 21	do	4.78	[illegible]
1902.			
Aug. 20	L. M. Lawson	.....	[illegible]

[a] New rod set July 20, 1898.

Discharge measurements of Stanislaus River at Parrots Ferry.

Date.	Hydrographer.	Discharge
1899.		*Sec.-feet*
Sept. 13	S. G. Bennett	[illegible]

imated monthly discharge of Stanislaus River at Oakdale, Stanislaus County. [a]

[Drainage area, 1,051 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1878.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
vember [b]			42	2,499	0.04	0.04
:ember [b]			42	2,582	.04	.05
1879.						
ıuary [b]			525	32,281	.50	.58
bruary	9,830	350	1,994	110,741	1.89	1.97
ırch	6,960		4,523	278,108	4.30	4.96
ril	7,390	3,260	4,307	256,284	4.09	4.56
ıy	6,060	2,950	4,098	251,976	3.90	4.50
ne	6,720	3,160	4,387	261,044	4.17	4.65
ly	2,230	1,320	1,584	97,396	1.51	1.74
ıgust [b]			126	7,747	.12	.14
ptember [b]			21	1,249	.02	.02
:tober [b]			21	1,291	.02	.02
›vember [b]			74	4,403	.07	.08
:cember [b]			630	38,737	.60	.69
The year			1,858	1,341,257	1.77	23.91
1880.						
ınuary [b]			315	19,369	0.30	0.35
:bruary [b]			526	30,256	.50	.53
arch [b]			630	38,737	.60	.69
pril [b]			5,781	343,993	5.50	6.14
ay	10,980	4,370	7,251	445,846	6.90	7.96
ıne	10,820	5,240	7,742	460,681	7.37	8.22
ıly	4,630	1,680	3,255	200,142	3.10	3.57
ugust			735	45,193	.70	.81
:ptember			74	4,403	.07	.08
ctober			32	1,967	.03	.03
ovember [b]			21	1,249	.02	.02
ecember [b]			630	38,737	.60	.69
The year			2,249	1,630,573	2.14	29.09

[a] Authority: California State engineering department from November, 1878, to October, 1884; nited States Geological Survey from June, 1895, to December, 1900.

[b] Estimated from run-off of neighboring streams and from previous measurements.

Estimated monthly discharge of Stanislaus River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1881.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January [a]			2,102	129,247	2.00	2.3
February [a]			5,255	291,847	5.00	5.2
March [a]			2,102	129,247	2.00	2.3
April [a]			4,729	281,394	4.50	5.0
May [a]			5,255	323,117	5.00	5.7
June [a]			2,733	162,625	2.60	2.9
July			960	59,028	.91	1.0
August			360	22,136	.34	.4
September			140	8,330	.13	.1
October			120	7,378	.11	.1
November			150	8,925	.14	.2
December			1,488	91,493	1.42	1.6
The year			2,116	1,514,767	2.01	27.3
1882.						
January			398	24,472	0.38	0.4
February			908	50,428	.86	.9
March			4,771	293,357	4.54	5.2
April			3,782	225,044	3.60	4.0
May			5,155	316,968	4.91	5.6
June [a]			5,255	312,694	5.00	5.6
July [a]			1,892	116,334	1.80	2.0
August [a]			105	6,456	.10	.1
September [a]			105	6,248	.10	.1
October [a]			473	29,083	.45	.5
November [a]			368	21,897	.35	.4
December [a]			210	12,912	.20	.2
The year			1,951	1,415,893	1.85	25.2

[a] Estimated from run-off of neighboring streams and from previous measurements.

Estimated monthly discharge of Stanislaus River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1883.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January			525	32,281	0.50	0.58
February [a]			420	23,325	.40	.42
March [a]			840	51,649	.80	.92
April [a]			2,102	125,078	2.00	2.23
May [a]			5,255	323,117	5.00	5.76
June [a]			4,204	250,155	4.00	4.46
July [a]			1,051	64,623	1.00	1.15
August [a]			315	19,368	.30	.35
September [a]			210	12,496	.20	.22
October [a]			168	10,330	.16	.18
November [a]			210	12,496	.20	.22
December [a]			210	12,912	.20	.23
The year			1,292	937,330	1.23	16.72
1884. [a]						
January			268	16,171	0.25	0.29
February			3,153	181,362	3.00	3.24
March			4,204	258,494	4.00	4.61
April			4,729	281,394	4.50	5.02
May			4,729	290,775	4.50	5.19
June			5,255	312,694	5.00	5.58
July			4,204	258,494	4.00	4.61
August			1,051	64,623	1.00	1.15
September			210	12,496	.20	.22
October			158	9,715	.15	.17
1895.						
June	8,510	3,842	5,686	338,340	5.41	6.04
July	3,842	550	1,778	109,330	1.69	1.95
August	550	145	330	20,304	.31	.36
September	3,161	145	638	37,970	.61	.68
October	246	145	176	10,802	.17	.19
November	179	179	179	10,651	.17	.19
December	414	145	198	12,208	.19	.22

[a] Estimated from run-off of neighboring streams and from previous measurements.

Estimated monthly discharge of Stanislaus River, etc.—Continued.

Month.	Discharge.			Total discharge	Run-off
	Maximum.	Minimum.	Mean.		Per square mile
1896.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*
January	6,956	150	1,806	111,058	1.72
February	1,208	632	782	45,038	.75
March	12,000	694	2,464	151,505	2.35
April	9,050	1,966	3,274	194,870	3.11
May	13,050	2,290	4,717	290,092	4.57
June	11,000	2,656	6,541	389,247	6.22
July	3,156	470	1,293	79,503	1.23
August	2,412	218	385	23,703	.37
September	962	252	332	19,761	.32
October	370	218	239	14,695	.22
November	4,514	252	705	41,968	.67
December	1,750	470	681	41,904	.65
The year	13,050	150	1,935	1,403,344	1.85
1897.					
January	2,251	410	609	37,446	0.58
February	10,580	1,264	3,252	180,607	3.10
March	5,062	1,264	1,915	117,750	1.82
April	9,234	1,880	5,064	301,328	4.81
May	9,980	5,480	7,324	450,338	6.97
June	3,974	860	2,077	123,590	1.98
July	1,180	250	582	35,786	.55
August	230	170	198	12,175	.19
September	190	140	152	9,045	.14
October	250	140	176	10,822	.17
November	780	170	255	15,174	.24
December	1,516	210	411	25,272	.39
The year	10,580	140	1,835	1,319,333	1.74

Estimated monthly discharge of Stanislaus River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1898.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
ıuary	336	74	207	12,728	0.20	0.23
bruary	1,372	156	389	21,604	.37	.39
ırch	1,000	336	572	35,171	.54	.62
ril	3,920	536	1,813	107,881	1.73	1.93
ıy	2,540	536	1,378	84,730	1.31	1.51
ne	880	480	647	38,499	.62	.69
ly	384	74	167	10,268	.16	.18
ıgust	100	27	66	4,058	.06	.07
ptember	100	50	61	3,630	.06	.07
tober	100	74	77	4,735	.07	.08
vember	100	50	71	4,225	.07	.08
cember	315	74	139	8,547	.13	.15
The year	3,920	27	466	336,076	.44	6.00
1899.						
nuary	1,240	70	457	28,100	0.44	0.51
bruary	690	130	355	19,716	.34	.35
arch	13,940	220	2,425	149,108	2.31	2.66
pril	5,270	1,450	3,525	209,752	3.35	3.74
ay	5,780	1,450	2,559	157,848	2.43	2.80
ne	4,632	1,045	2,663	158,459	2.53	2.82
ly	1,120	175	502	30,867	.48	.55
ugust	265	90	150	9,223	.14	.16
ptember	130	50	85	5,058	.08	.09
ctober	1,200	90	309	19,000	.29	.33
ovember	2,340	90	1,092	64,978	1.04	1.16
ecember	5,015	550	1,461	89,834	1.39	1.60
The year	13,940	50	1,299	941,443	1.24	16.77

Estimated monthly discharge of Stanislaus River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off	
	Maximum.	Minimum.	Mean.		Per square mile.	
1900.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	
January	7,050	820	1,944	119,532	1.85	
February	1,100	540	700	38,876	.67	
March	2,640	540	1,829	112,461	1.74	
April	3,000	1,260	1,761	104,787	1.68	
May	4,377	1,260	3,343	205,553	3.18	
June	3,125	960	1,863	110,856	1.77	
July	960	70	349	21,459	.33	
August	110	30	64	3,935	.06	
September	70	30	46	2,737	.04	
October	2,760	70	448	27,546	.43	
November	6,037	310	1,220	72,595	1.16	
December	1,640	610	871	53,556	.83	
The year	7,050	30	1,203	873,893	1.15	

Discharge measurement of Cascade Creek, Stanislaus River, Tuolumne County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Oct. 21, 1896	J. B. Lippincott	

Discharge measurement of Cow Creek, Stanislaus River, Tuolumne County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Oct. 21, 1896	J. B. Lippincott	

Discharge measurement of Stanislaus River, Main Fork, Eureka Valley, Tuolumne County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
)v. 20, 1896	J. B. Lippincott	158.0

Discharge measurement of Mill Creek, Stanislaus River, Tuolumne County.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
t. 21, 1896	J. B. Lippincott	1.5	

scharge measurement of Niagara Creek, Stanislaus River, Tuolumne County.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
t. 21, 1896	J. B. Lippincott	1.5	

scharge measurement of Stanislaus River, Middle Fork, Donnels Flat, near mouth of Niagara Creek, Tuolumne County.

Date.	Hydrographer.	Discharge.	Remarks.
		Sec.-feet.	
t. 12, 1899	Mr. Coul	144	Mean of 12 measurements not influenced by reservoired water; no diversion above.

scharge measurement of Stanislaus River, Middle Fork, north of Shot Gun, Tuolumne County.

Date.	Hydrographer.	Discharge.	Remarks.
1901.		*Sec. feet.*	
pt. 16, 17	C. E. Moore	300	

Discharge measurement of Stanislaus River, Oakdale Ditch Company's Flu Stanislaus County.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks
1899.		*Feet.*	*Sec.-feet.*	
May 19	S. G. Bennett		10.6	
1902.				
May 12	S. G. Bennett	23	36.0	Flume No. 13, main canal b low head of Oakdale Can
Do	do		73.0	Flume No. 6, main canal b low head of Oakdale Can
Do	do		13.71	

Discharge measurements of Stanislaus Water Company's Canal, Stanislaus Riv near Knights Ferry, Stanislaus County.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1896.		*Feet.*	*Sec.-feet.*	
Sept. 8	H. Crowe		66	
Oct. 30	J. B. Lippincott		38	
1897.				
Feb. 16	J. B. Lippincott		26	Below forks.
Do	do		13	Little John Canal.
	Total		39	
May 30	J. B. Lippincott		54	Main canal below forks.
Do	do		12	Little John Canal.
	Total		66	
July 13	A. Q. Campbell		36	Below forks.
Do	do		15	Little John Canal.
	Total		51	
Sept. 6	A. Q. Campbell		52	Below forks.
Do	do		1	Little John Canal.
	Total		53	
Oct. 29	A. Q. Campbell		35	Below forks.
Do	do		1	Little John Canal.
	Total		36	
Dec. 19	J. B. Lippincott		17	Below forks.
Do	do		4	Little John Canal.
	Total		21	

ischarge measurements of Stanislaus Water Company's Canal, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1898.		*Feet.*	*Sec.-feet.*	
pr. 17	J. B. Lippincott		58	
ne 1	do		72	Main canal flume No. 3.
ly 29	do		42	Do.
ct. 5	do		33	
ct. 6	do		33	
1899.				
ay 19	S. G. Bennett		74	Do.
ne 6	do		71	Do.
1900.				
ay 9	S. G. Bennett	2.79	95	Do.
pt. 7	do		85	At headworks of canal.
1902.				
ay 12	S. G. Bennett	1.14	129	Flume No. 3, main canal.
ug. 16	E. T. Perkins		3.5	San Antonio Creek below mouth of Big Tree Creek.
ug. 17	do		67	Angel's ditch near head North Fork Stanislaus.
Do	do		1	North Fork, 400 feet below suspension bridge.
	Total		68	
ug. 17	E. T. Perkins		2.3	Mill Creek at junction Love and Morgan creeks.
ug. 20	do		54	Power company's flume above ditch tender's house, South Fork.
Do	do		16	Do.
ug. 21	do		53	Clarks Fork at mouth Middle Fork.
Do	do		126	Middle Fork below mouth of Clarks Fork.
Do	do		73	Middle Fork above mouth of Clarks Fork.
ug. 14	do		53	Standard ditch at flume No. 59.
ug. 22	L. M. Lawson		193	Below Colliers.
ug. 24	do		170	Abbotts ferry.
ug. 21	do	.6	168	Parrotts ferry.
ug. 23	do		171	Robinsons ferry.
ug. 19	do		166	Knights ferry.
ug. 17	do		154	Stanislaus Water Co.'s canal below intake.

Discharge measurements of Stanislaus Water Company's Canal, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.	Remarks.
1900.		*Feet.*	*Sec.-feet.*	
Sept. 7	S. G. Bennett		[a] 28	At headworks Stanislaus Water Co.'s Canal, 6 miles above Knights Ferry.
Sept. 7	do		[b] 85	
	Total		113	

[a] River. [b] Canal.

Discharge measurements of Stanislaus River, Tuolumne County.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
1896.		*Feet.*	*Sec.-feet.*	
Sept. 3	J. B. Lippincott		60	South Fork at Sugar Pine. In flume; not entire flow of river.
1901.				
Sept. 17	C. E. Moore		300	Middle Fork, 15 miles above junction with North Fork.

STONY CREEK.

This stream drains 700 square miles of the eastern slopes of the Coast Range. After reaching the Sacramento Valley it flows west for a number of miles, contrary to the general drainage, and then turns eastward and enters the Sacramento River 20 miles below Vina, Cal. A large portion of the basin near the heads of the streams is heavily covered with commercial timber. There are a number of good reservoir sites on this stream and its tributaries.

On January 30, 1901, a gaging station was established by Mr. B. J. Cole at Julian's ranch, 6 miles northwest of the town of Fruto, Cal., to determine the amount of water available for storage.

For a description in detail of the reservoir sites and drainage basin of Stony Creek, see Water-Supply and Irrigation Paper No. 86.

Discharge measurements of Stony Creek, Glenn County, Cal.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
		Feet.	*Sec.-feet.*	
g.. 1900[a]				
)t.. 1900[a]	Burt Cole		0.0	Grindstone Creek, 4 miles above mouth.
t.. 1900[a]				
v. 22, 1901	H. E. Green		38.0	Grindstone Creek, point above bridge.
g. 3, 1900	Burt Cole		1.7	Hall ditch.
)t. 30, 1900	do		1.4	Hall ditch, 100 feet above head gate.
ly 28, 1900	do		2.3	Orland ditch.
g. 3, 1900	do		1.7	Do.
)t. 30, 1900	do		1.3	Do.
)t. 22, 1900	S. G. Bennett		7.7	1 mile below Elk Creek.
g.. 1900[a]				
)t.. 1900[a]	Burt Cole		.0	Briscoe Creek, at mouth.
t.. 1900[a]				
v. 22, 1901	H. E. Green		10.4	Briscoe Creek, above dam site.
)t. 21, 1900	Burt Cole		13.8	Brown ditch.
)t. 1, 1899	W. W. Brier		3.25	Thomas Creek, Tehama County, at Richfield Station.
v. 11, 1900	Burt Cole		62.0	Gaging station, Julian's ranch.
b. 19, 1901	do		18,000.0[b]	
b. 27, 1901	do	6.9	2,583.0	Do.
r. 9, 1901	do	5.6	933.0	Do.
r. 30, 1901	S. G. Bennett	4.9	382.0	Do.
)t. 3, 1901	do	3.17	3.4	Do.
v. 21, 1901	H. E. Green	4.3	165.0	Do.
a. 26, 1902	S. G. Bennett	3.9	126.0	Do.
b. 28, 1902	do	10.0	7,336.0	Do.
y 8, 1902	S. G. Bennett	5.33	1,080.0	Do.
)t. 24, 1902	do	3.00	14.0	Do.
)t. 21, 1900	B. Cole		.3	Laux ditch.
Do	do		20.0	Stony Creek, near Stony Fork, above Laux ditch.
)t. 26, 1900	do		6.2	Stony Ford ditch, at headgate.
)t. 21, 1900	do		.3	Welton ditch headgate.

[a] Dry. [b] Estimated.

Estimated monthly discharge of Stony Creek at Julian's ranch.

[Drainage area, 760 square miles.]

Month.	Discharge.			Total discharge.	Run-off	
	Maximum.	Minimum.	Mean.		Per square mile.	
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	
February	10,385	725	2,707	150,339	3.56	
March	2,215	435	893	54,908	1.18	
April	630	225	361	21,481	.48	
May	555	225	349	21,459	.46	
June	195	5	66	3,927	.09	
July	15	0	7	430	.01	
August	10	2	4	246	.01	
September	725	5	35	2,083	.05	
October	340	0	130	7,993	.17	
November	1,125	35	161	9,580	.21	
December	3,875	77	425	26,132	.56	
11 months	10,385	0	428	298,578	.57	
1902.						
January	150	109	114	7,010	0.15	
February	14,650	109	4,201	233,312	5.53	
March	7,000	920	2,588	159,130	3.41	
April	4,680	690	1,522	90,565	2.00	
May	1,000	270	578	35,540	.76	
June	370	5	132	7,855	.17	
July	9	2	3	184	0	
August	5	2	3	184	0	
September	14	5	9	536	.01	
October	225	55	92	5,657	.12	
November	5,005	109	1,584	94,255	2.08	
December	2,765	690	1,132	69,604	1.49	
The year	14,650	2	997	703,832	1.31	

SUSAN RIVER.

Discharge measurements of Susan River at Honey Lake Basin, Lassen County.

Date.	Hydrographer.	Gage height.	Discharge.	Locality.
1899.		*Feet.*	*Sec.-feet.*	
Mar. 18	Albert Halen		25.0	Mouth of Willow Creek.
Mar. 18	W. D. Minckler		25.0	Do.
Mar. 23	Albert Halen		28.0	Do.
June 4	do		25.0	Do.
Mar. 24	W. D. Minckler		28.0	Willow Creek, near Ravencrofts.
June 4	do		24.0	Do.
June 11	Albert Halen		21.0	Do.
June 11	W. D. Minckler		21.0	Do.
1900.				
June 4	L. H. Taylor	2.60	16.0	Do.
July 30	do	2.85	26.0	Do.
Oct. 10	do	2.80	20.0	Do.
1899.				
Mar. 18	Albert Halen		139.0	Main river, dam near mouth of Willow Creek.
Mar. 23	do		115.0	Do.
June 4	do		37.0	Do.
June 11	do		33.0	Do.
June 11	do		34.0	Main river, below dam.
Mar. 18	W. D. Minckler		14.5	Do.
Mar. 23	do		41.0	Do.
June 11	do		34.0	Main river, below Colony dam.
	do		23.0	Do.
1900.				
June 30	L. H. Taylor	3.20	40.0	Near Susanville.
July 5	do	2.60	8.0	Do.
1901.				
Mar. 16	do	4.30	274.0	Do.
Apr. 5	do	4.00	178.0	Do.
May 20	do	4.50	351.0	Do.
June 7	do	3.60	84.0	Do.

Discharge measurements of Susan River at Honey Lake Basin, etc.—Continued.

Date.	Hydrographer.	Discharge.	Locality.
1899.		*Sec.-feet.*	
June 11	W. D. Minckler	33.00	North and South branches above Colony dam.
Apr. 24	do	31.00	South Branch, Otis Johnson's.
June 4	do	30.00	Do.
Apr. 4	do	11.00	North Branch, Otis Johnson's
June 4	do	7.00	Do.
Apr. 18	do	30.00	Tanners Slough.
Apr. 23	do	27.00	Do.
June 4	do	15.00	Do.
June 11	do	18.00	Do.

SUTTER RIVER.

Discharge measurement of Sutter River, Amador County.

Date.	Hydrographer.	Discharge.	Locality.
1899.		*Sec.-feet.*	
Sept. 18	S. G. Bennett	1.6[illegible]	At Sutter Creek (estimated).

SWEETWATER RIVER.

The drainage basin of Sweetwater River is in the extreme southwestern corner of the United States, being in San Diego County, Cal., adjacent to the Republic of Mexico. The river flows from the western slope of Cuyamaca Mountain, which rises to an elevation of 6,000 feet. The city of San Diego, on the coast, is about 33 miles west and [illegible] miles south of this peak. The drainage basin is 34 miles in length by about 5 miles in width, its total area above the reservoir being [illegible] square miles, as determined in part from survey and in part from [illegible] county maps. This area is classified as follows:

	Sq. [illegible]
Steep and rocky mountains favorable to large run-off	[illegible]
Lower rolling mountains, usually covered with brush	[illegible]
Rolling hills, covered with soil and disintegrated granite	[illegible]
Agricultural lands (17 per cent) and river bottom	[illegible]
Total	[illegible]

The most noticeable topographic feature of this basin influencing the run-off is the abrupt flattening of the slopes at the base of the mountains into agricultural fields. The drainage lines deeply cut into the steep hillsides are quickly lost or are poorly defined in crossing the [illegible]

lluvial cones or partly filled valleys on the low grounds. In turn, ıe nearly level fields or parks drain into deep canyons. The occaonal flood caused by a heavy rain rushing down the mountain side ›reads out over the flat lands, much of it disappearing before it can ›ach the lower canyon. The steady percolation which might be xpected at points below is to a large extent cut off by the high rate f evaporation, and thus the percentage of run-off, taking the basin as whole, is small. A more detailed description of this river is given ı William Ham. Hall's report on irrigation in southern California.

The figures relating to the amount of water draining from this basin nd also the other details given in the following table have been comiled from data obtained by Mr. H. N. Savage, chief engineer, and Ir. James D. Schuyler, consulting engineer, of the San Diego Land nd Town Company. The first column in the table gives the evaporaon from the surface of the Sweetwater reservoir in inches in depth er month. This was measured from a metallic pan exposed to the irect rays of the sun at a point near the dam, this being continued in se until May, 1893. Subsequently observations were made by means f a Piche evaporometer.[a] This was placed in an instrument shelter f the ordinary type used by the Weather Bureau. This shelter is 15 ›et above the ground and about 40 feet above the level of the lake, eing located 500 feet northeast from the gate tower. It has been oted that the records from the Piche evaporometer which cover the ame months as those from the pan are in the ratio of 48 to 57. It is elieved that the exposed pan gives more nearly the evaporation from he water surface than the Piche evaporometer. If the evaporation ›ere annually 5 feet in depth from the surface of the reservoir—that ›, from the 70-foot level down to the 65-foot level—the loss would mount to 24 per cent of the total amount stored. The area of the eservoir at the 70-foot level is 721.86 acres.

The average wind velocity given in miles per hour is that noted at he city of San Diego, 12 miles from the reservoir, and under similar onditions. In this connection it may be well to note the results btained by Prof. Thomas Russell as to the effect of velocity upon vaporation obtained by whirling the Piche evaporometer at varying ates.

Experiments were made which show that the effect of the wind on the evaporaion from a vessel exposed in the open air is very great. Two Piche instruments ›ere taken, one suspended in quiet air and the other fixed rigidly on the end of the 8-foot arm of the whirling machine set up in the inclosure of the Pension Office uilding. The whirling machine was the one used in standardizing anemometer.

The instruments, filled with water, were first weighed on a fine balance to the undredth of a gram. The whirling arm was then turned so that the Piche on ts end moved with a velocity of 5 miles an hour. The motion was continued for

[a] Described by Prof. Thomas Russell in the Monthly Weather Review for September, 1888, in onnection with a report upon the depth of evaporation in the United States.

half an hour, and at the end of the time both Piches were again weighed. The the Piche that had been suspended in quiet air was put on the arm, and the one that had been on the arm was put in its place. The whirling was then started again at the same velocity, and continued for another half hour. At the end of the time the Piches were again weighed. While this was being done the humidity of the air was determined from time to time by means of whirled wet and dry bulb thermometers.

Observations were also made in the same way with the Piche moving at velocities of 10, 15, 20, 25, and 30 miles per hour. At a velocity of 5 miles an hour the evaporation from a Piche was 2.2 times that from one in quiet air; at 10 miles, 3.8 times; at 15 miles, 4.9 times; at 20 miles, 5.7 times; at 25 miles, 6.1 times; and at 30 miles, 6.3 times. During the time the observations were made, June 25 and 26, 1888, the average temperature of the air was 83.7 and the relative humidity 50 per cent.

Measurements were made of the relative humidity at the reservoir during 1893 and 1894. When not obtained at this point they are given from the Weather Bureau figures for San Diego. The temperature of the air is taken as the average of the maximum and minimum daily readings. The temperature of the water in the lake and also in the pan was taken daily. That in the pan was observed at about 2 p. m., thus giving a reading slightly higher than that of the lake, as the pan under the hot sun caused the water to warm slightly. If two readings had been taken each day at intervals of twelve hours the average would probably have been very nearly that of the lake. It is noted that the water in the lake was usually a few degrees warmer than the atmosphere.

RAINFALL IN SWEETWATER BASIN.

The rainfall has been measured at two rain gages, one at the reservoir and one at Descanso, 25 miles east of the reservoir and at an elevation of 3,500 feet. The Descanso gage is 3 miles to the east of the summit of a ridge which may act in such a manner as to cut off the precipitation, thus reducing it below a theoretical amount for this position. In addition to the two rain gages within the drainage basin, the record from a third—that at the Cuayamaca reservoir—is given. This is at an elevation of 4,800 feet, and is only 3 miles distant from the divide between the drainage of Sweetwater and of San Diego River. The gage here is in a narrow valley or canyon, and the results obtained, being probably influenced by local topography, are regarded as excessive for this altitude and the locality. The rainfall at the dam in the winter of 1900–1901 was 11 inches.

The total amount of precipitation, as obtained at the reservoir and at Descanso, is not considered as showing the rainfall upon the drainage basin as a whole. One of the gages is located too high and the other too low to fairly represent the average conditions. In order, therefore, to obtain approximately the total amount of water falling upon the basin, certain assumptions are made and corrections are

pplied to the recorded precipitation. It is assumed that there is a gular increase in the rate of precipitation with altitude, and that his is at the rate of 0.6 inch of rain for each 100 feet increase in evation. It is also assumed that the mean elevation of the whole asin is approximately 2,200 feet. Taking San Diego, which is nearly t sea level, as the base station, this, under the assumptions just iven, would indicate that the rainfall on the basin should average 3.2 inches greater than that at San Diego. As the average rainfall t San Diego is 9.92 inches, the rainfall on the Sweetwater catchment rea should be 9.92 plus 13.2 inches, or 23.12 inches.

In the same way the average rainfall is deduced from the measurements at the points within the basin. At Descanso the average rainall is 26.38 inches. This point, having an altitude of 3,500 feet, is ,300 feet above the assumed altitude of Sweetwater basin. Deducting, therefore, 7.8 inches leaves 18.58 inches as the average rainfall. gain, taking the results obtained at the rain gage at the Sweetwater eservoir, 12.01 inches, at an elevation of 250 feet, and adding to this he theoretical increase due to altitude of 11.70 inches, the sum 23.71 an be applied to the basin. The average of these two computations, ased on the observations at Descanso and at the reservoir, is 21.14 nches for the basin. This method has been used in the following able, page 351, in determining the average rainfall throughout the 186 quare miles in the catchment basin for each year, additions being nade to the rainfall recorded at the reservoir, and subtractions from hat at Descanso, the average of the two results thus obtained being iven in the table.

RUN-OFF FROM SWEETWATER BASIN.

The discharge from this watershed, embracing 186 square miles, luring the winter of 1900–1901, was 280,000,000 gallons, or 861 acreeet.

The run-off shown in the table on page 351 has been computed by Ir. H. N. Savage. The stream usually ceased flowing about the 1st f June and remained dry throughout the summer, water flowing gain in the fall or early winter after the rains began. At this latter ime the reservoir is at a low stage, the water having been used for rrigation during the hot season. The flow into the reservoir, being holly held, is therefore computed from the increase of height shown y the readings on the gage rod in the reservoir, due allowance being nade for evaporation and the amount withdrawn. Later, when the eservoir is full and some of the water overflows, an additional amount nust be added. To obtain this amount is a somewhat difficult matter, s the water flows out through a gate valve, over the waste weir, and lso occasionally, during floods, over the top of the dam.

Evaporation, temperature, and rainfall at Sweetwater reservoir, San Diego County.

Month.	Evaporation.	Wind (miles per hour).	Humidity.	Temperature.		Rainfall.		
				Air, degrees Fahrenheit.	Water, degrees Fahrenheit.	At reservoir.	At Descanso.	At Cuyamaca
1888.	*Inches.*		*Per cent.*			*Inches.*	*Inches.*	*Inches*
September				70		0.00		
October				65		.36		
November				60		2.81		
December				58		3.20		
1889.								
January	1.990	4.8	80	57		1.56		
February	3.336	5.7	74	56		.82		
March	3.380	5.4	80	59		3.87		
April	4.961	5.6	79	61		.36		
May	5.822	5.9	75	61		.21		
June	6.806	*5.5	81	64		.33		
July	7.398	5.1	79	67		.01		
August	8.253	5.0	69	73		.00		
September	7.360	5.1		71		.00		
October	2.998	4.7		65		2.22		
November	4.800	4.4		60		1.08		
December	.246	4.7		56		7.07		
1890.								
January	1.588	5.0		48		2.20		
February	2.214	5.2		52		2.07		
March	3.280	4.9		55		1.30		
April	4.141	5.1		58		.10		
May	6.140	4.6		60		.41		
June	7.302	5.4		65		.00		
July	7.380	4.7		70		.00		
August	9.020	4.6		71		.07		
September	6.482	4.3	69	72		.42		
October	4.920	4.0	79	66		.45		
November	5.535	4.3	59	65		.93		
December	1.845	4.5	83	62		2.29		
1891.								
January	3.608	4.4	58	55		.83		
February	1.353	5.8	73	52		5.28		
March	3.075	5.3	74	57		.23		
April	3.707	4.9	76	58	70	1.27		

Evaporation, temperature, and rainfall at Sweetwater reservoir, etc.—Continued.

Month.	Evaporation.	Wind (miles per hour).	Humidity.	Temperature.		Rainfall.		
				Air, degrees Fahrenheit.	Water, degrees Fahrenheit.	At reservoir.	At Descanso.	At Cuyamaca.
1891.	*Inches.*		*Per cent.*			*Inches.*	*Inches.*	*Inches.*
May	5.599	5.4	75	61	69	0.83	.....	3.69
June	6.027	4.6	74	65	78	.09	.....	.00
July	5.501	4.0	78	71	80	.00	.....	.04
August	8.890	3.8	77	73	82	.03	.....	.30
September	6.150	4.7	76	73	76	.00	.....	2.67
October	6.314	3.8	79	66	72	.00	.....	.00
November	4.100	3.8	74	60	64	.13	.....	.45
December	2.752	5.4	65	52	54	.90	.....	6.75
1892.								
January	2.542	3.7	58	55	54	2.42	.....	7.23
February	1.394	4.7	75	54	63	3.47	.....	6.47
March	3.075	4.8	73	56	66	.55	.....	7.76
April	5.822	5.5	82	57	70	.93	.....	3.35
May	4.674	5.7	68	61	71	1.39	.....	5.90
June	6.478	5.6	69	63	74	.07	.....	.67
July	8.808	5.0	73	67	78	.00	.....	.00
August	6.540	4.9	74	68	78	.02	.....	.00
September	6.273	4.8	74	68	76	.00	0.00	.00
October	6.560	4.2	65	64	[a]68	.15	.00	.30
November	4.766	3.7	50	62	60	.04	1.50	2.87
December	2.614	4.3	66	53	56	2.12	2.00	3.76
1893.								
January	2.768	4.0	51	57	58	.22	3.01	5.55
February	2.214	5.1	67	54	59	1.96	2.64	9.13
March	1.076	6.2	76	51	60	6.50	14.07	15.60
April	5.002	5.3	73	58	64	.27	.50	1.00
May	4.902	5.8	72	61	68	.20	.00	1.00
June	3.411	4.9	77	65	76	.00	.00	.00
July	5.318	5.1	77	69	81	.16	.75	1.20
August	4.693	5.0	75	72	80	.00	.00	.30
September	4.864	5.1	75	66	77	.00	.25	.00
October	4.586	4.6	67	65	70	.33	1.25	1.90
November	4.513	4.5	65	58	60	.84	3.15	3.30
December	6.283	4.5	60	58	58	2.08	4.38	6.05

[a] End of measurements from pan and beginning of observations on Piche evaporometer.

Evaporation, temperature, and rainfall at Sweetwater reservoir, etc.—Continued

Month.	Evaporation.	Wind (miles per hour).	Humidity.	Temperature.		Rainfall.		
				Air, degrees Fahrenheit.	Water, degrees Fahrenheit.	At reservoir.	At Descanso.	At [illegible]
1894.	*Inches.*		*Per cent.*			*Inches.*	*Inches.*	*Inches.*
January	3.897	5.0	68	50	52	0.36	2.10	2.6
February	3.533	5.2	67	50	56	.71	3.40	2.5
March	3.008	5.8	73	56	59	1.69	3.63	3.0
April	3.634	5.4	70	59	65	.04	.13	.0
May	3.451	5.7	74	59	68	.15	.50	1.0
June	4.683	5.6	72	62	76	.00	.38	.5
July	3.161	5.2	75	67	80	.00	.12	.0
August	3.066	4.8	77	68	82	.00	.13	1.7
September	4.687	5.1	76	69	75	.00	.00	.4
October	3.232	3.8	72	64	70	.04	.00	.0
November	3.847	3.9	76	59	64	.00	.00	.0
December	2.344	4.3	73	54	59	3.03	7.62	12.5
1895.								
January	2.357	6.0	74	53	.....	9.63	19.52	25.4
February	2.850	5.0	.....	54	.....	1.52	2.76	4
March	3.121	5.3	.....	56	.....	1.18	3.13	5.5
April	3.939	5.2	.....	58	.....	.44	.64	1.2
May	4.119	5.8	77	63	.....	.35	.63	.7
June	3.188	.....	.....	66	.....	.00	.00	.0
July	[a]6.428	.....	.....	69	.....	.00	.00	.0
August	[a]6.744	.....	.....	71	.....	.00	.00	.0

[a] Estimated.

The following table gives, for the period from 1888 to 1901, the estimated precipitation upon the catchment basin, obtained as stated on age 347, also the depth of run-off in inches and the relation which his bears to the depth of rainfall, by years. The years chosen are ot calendar years, but extend from September to August, inclusive, s this division is more in accordance with the distribution of rainfall nd the discharge of the streams.

Estimated rainfall upon the Sweetwater catchment basin; also depth and percentage of run-off.

Year.	Rain.	Run-off.		Per cent.
		Per square mile.	Inches.	
	Inches.	*Sec.-feet.*		
1887–88		0.0524		
1888–89	21.00	.1875	2.54	12.000
1889–90	25.71	.1525	3.71	14.000
1890–91	23.40	.1602	2.07	9.000
1891–92	17.14	.0460	.62	4.000
1892–93	20.00	.1210	1.61	8.000
1893–94	14.76	.0099	.14	1.000
1894–95	27.14	.5452	7.12	26.000
1895–96	19.54	.0098	.101	.517
1896–97	24.91	.0512	.665	2.67
1897–98	18.18	.00003	.0005	.003
1898–99	18.51	.0018	.025	.135
1899–1900	19.10	0	0	0
1900–1901	23.65	.0063	.087	.368
1901–1902	20.29	0	0	0

The figures showing evaporation, wind movement, humidity, and temperature are brought together for comparison by years in the following table. In this case, as stated above, the years extend from September to August, inclusive, as this most nearly agrees with the natural division.

Annual evaporation, temperature, etc., in Sweetwater Basin.

[Elevation of reservoir, 250 feet.]

Period.	Evaporation.	Wind.	Humidity.	Temperature of air.	Temperature of water
	Inches.	*Miles per hour.*	*Per cent.*	*Deg. F*	*Deg. F*
1888–89					
1889–90	56.47	4.9			
1890–91	57.54	4.6			
1891–92	58.65	4.8	72	61	
1892–93	49.60	4.9	68	61	
1893–94	48.68	5.1	70	60	
1894–95	46.31	5.2	79	59	
1895–96	45.18	5.2	71	61	
1896–97	[a]41.24	5.3	76	61	
1897–98	61.93	5.9	73	60	
1898–99	[b]32.54	5.8	72	59	
1899–1900		5.7	75	61	
1900–1901				62	

[a] Evaporation January 1 to August 31. [b] Evaporation September 1 to April 1.

FLOODS IN THE RIVER.

The Sweetwater, like the other rivers of southern California, is liable at times to extraordinary floods, due to heavy precipitation upon the catchment basin. In 1893 two floods furnished 70 per cent of the annual discharge of the river for that year. For the 24 hours ending March 24, 1893, the river discharged 3,069 acre-feet. For the seven days ending March 27, the total amount discharged was 7,980 acre-feet. In January, 1895, a flood was carefully watched and the flow computed at short intervals, as shown in the following table. The total run-off from 5 p. m. on January 14 to noon on January 22 was equivalent to a trifle over 4.70 inches over the whole drainage basin, or in all 46,670 acre-feet. This same storm gave a maximum discharge from Cedar, Boulder, and Colman creeks, aggregating 13 square miles within the drainage basin of San Diego River, of 13 second-feet.

Rate of flow during flood of January, 1895, in Sweetwater River.

Time.	Second-feet.	Time.	Second-feet.
anuary 14:		January 17—Continued.	
5 p. m	0	3 p. m	4,416
anuary 15:		January 18:	
7 a. m	84	8 a. m	3,331
12 m	1,855	9 a. m	2,090
3 p. m	6,410	10 a. m	2,048
4 p. m	5,214	7 p. m	2,466
5 p. m	5,262	January 19:	
6 p. m	4,152	5 a. m	1,532
7 p. m	6,185	8.30 a. m	2,944
9 p. m	5,567	9.30 a. m	2,888
10 p. m	5,080	10.30 a. m	3,068
anuary 16:		11.30 a. m	3,470
5 a. m	3,297	1.30 p. m	3,364
6 a. m	4,720	3 p. m	3,968
7 a. m	3,585	3.30 p. m	4,692
8.30 a. m	5,316	4 p. m	3,224
9.30 a. m	5,370	4.30 p. m	3,230
10.30 a. m	6,602	9 p. m	3,176
11.30 a. m	8,713	January 20:	
12.30 p. m	8,713	7 a. m	3,314
1.30 p. m	13,684	9 a. m	2,805
2 p. m	13,000	10 a. m	2,674
2.30 p. m	15,148	11 a. m	2,484
3.30 p. m	18,148	1 p. m	2,500
4 p. m	14,034	2 p. m	2,136
4.30 p. m	14,490	January 21:	
5.30 p. m	7,227	7 a. m	1,880
6.30 p. m	9,420	10 a. m	820
7.30 p. m	8,310	12 m	750
8 p. m	6,930	5.30 p. m	800
anuary 17:		January 22:	
5 a. m	5,302	7 a. m	810
6 a. m	3,545	12 m	530
8 a. m	3,954		

INCREASE OF PRECIPITATION WITH ALTITUDE.

In connection with the above data concerning the rainfall and run-f on the Sweetwater drainage basin, the writer has given a discus-on of the precipitation in southern California, and has brought

together figures showing the increase of rainfall with altitude. The following statement is quoted from a report made on this subject:

The warm, moisture-laden winds from the sea on their inland journey are driven up the slopes in the Coast Range. As they rise in elevation they expand under the lighter atmospheric pressure, become chilled, and are deprived of all moisture in excess of the point of saturation at that temperature and pressure. This lowering of temperature in their ascent is more pronounced in winter than in summer, and, coupled with the fact that a high barometer is normal off the coast of southern California during the summer season, the winds yield much less rain.

The year in California is naturally divided into a wet and a dry season, the dry season beginning about the 1st of May, with little rain falling, except in thunder storms in the high mountains, before the 1st of October. The rains then gradually increase, reaching their maximum in January. The records of the United States Signal Service and the Weather Bureau begin the year with the 1st of January. This is not a proper division in this region, as it will not show either the maximum or minimum years of rainfall. Engineers divide the year either with the 1st of July or the 1st of September.

The effect of topography on rainfall is given in a report by Prof. G. E. Curtis in the following words:

"In general the amount of rain increases with the elevation above sea level up to a maximum plane, after which a decrease takes place. S. A. Hill has shown that in the northwest Himalayas, where the rainfall is most remarkable in amount and rate of variation, the observations can be represented by the following empirical formula: $R=1+1.92\,h-0.40\,h^2+0.02\,h^3$, in which R represents the amount of rain and h the relative height in units of 1,000 feet above the assumed plane which is itself 1,000 feet above sea level. From this formula the height of maximum rainfall is computed to be 3,160 feet above the plane, or 4,160 feet above sea level. It is further shown that this elevation is that at which, according to the observed law of decrease of temperature, the southwest monsoon is cooled just below its dew-point. This point will be that at which in the mean we should expect the maximum precipitation to take place. * * * A very rapid diminution takes place on the leeward side, where the stations record only about half the amount of rainfall given by stations of equal elevation on the windward side."

Similar conditions prevail in California. In illustration the following table (p. 355) is given, in which the results obtained at a base station are compared with those from other stations in the vicinity and on that parallel. The base station in each case is one whose record is of long standing. In the table the second column gives the period during which the record has been kept. The third shows the elevation of the station above sea. The fourth gives the annual average recorded rain at that station. The fifth gives the relation of the rainfall at the base station, during the years that rainfalls were actually recorded at the station under consideration, to the total average rainfall recorded at the base station during its entire period of observation. The record at the second station is then adjusted by this ratio and a probable average rainfall is determined for the station considered and entered in the sixth column under the head "Probable mean rain." For example, take the station Poway. The record at this point is for ten years, while the record at the base station, San Diego, has been kept for a period

[a] Signal Service Notes. No. 16. The effect of wind currents on rainfall, by G. E. Curtis. Washington, 1884, pamphlet, 11 pp., pp. 6-7.

[b] See statement of Arthur Jacobs, late executive engineer for irrigation, Her Majesty's Navy Service, in Van Nostrand's Science Series, No. 6, p. 11.

y-five years. Now, the average annual rain for a period of forty-five years is ably nearer the actual average than that given by a record extending over a h less period. The two stations, being so near together and subject to the e general climatic conditions, have probably a close relation. If during the that the record has been kept at Poway the rain at San Diego is found to be per cent of the average of forty-five years, then the recorded rain at Poway sumed to be 117 per cent of the average there.

examining the data available, it has been found that the increase in precipi- n due to elevation is approximately at the rate of 0.6 of an inch of rain for 100 feet rise in elevation on the western slope of the Coast Range and of the ra Nevadas in California. There is also an increase due to elevation on the ern slope, but this is very much less in amount. The figures in the seventh mn in the table below have been obtained by adding the computed increase to elevation above the base station to the recorded rain at the base station. comparing these figures in the seventh column, showing theoretical rainfall, the recorded mean rainfall and the probable mean rainfall given in the th and sixth columns, the applicability of this deduced rate of increase of ipitation with altitude is shown.

Table showing the relation of rainfall to elevation in California.

Station.	Period.	Elevation.	Rainfall.			
			Recorded.	Per cent.	Probable mean.	Theoretical.
First group.		*Feet.*	*Inches.*		*Inches.*	*Inches.*
Diego [a]	1850–95	0	9.92			
etwater, reservoir	1888–95	250	12.37	103	12.01	11.42
ray	1878–89	460	13.38	117	11.43	12.68
canso	1889–95	3,500	26.65	101	26.38	30.92
an	1879–84	4,500	37.75	130	29.04	36.92
amaca	1887–95	4,800	44.66	102	43.79	38.72
Second group.						
Angeles [a]	1871–94	330	16.96			
r Valley, reservoir	1883–94	6,000	54.03	110	49.09	50.92
Third group.						
ramento [a]	1849–89	31	19.90			
urn	1870–84	1,360	32.72	102	32.08	27.78
fax	1870–84	2,422	44.81	102	43.93	34.20
o	1870–84	5,934	57.41	102	56.28	55.20
mit	1870–84	7,017	47.93	102	46.99	61.80
Fourth group.						
ckee	1870–84	5,919	29.53	102	28.95	54.60
o	1870–91	4,497	5.17	102	5.07	46.56
dsworth	1870–91	4,085	3.83	102	3.75	44.28

[a] Base stations.

The stations of the first and second groups are located in San Diego County, and are all on the western slope of the Coast Range. Bear Valley is 80 miles east of Los Angeles on the same slope. The third group comprises the stations along the Central Pacific from Sacramento east to the summit, and the fourth those along the same line of road on the eastern slope 14, 49, and 83 miles by rail beyond the summit. This fourth group is given to show that wholly different conditions prevail on the eastern and on the western slope of the mountain.

All these records are seasonal, the year being divided at the 1st of September when possible. Data are given from Signal Service and Weather Bureau reports and from those of the California State engineer, the former being accepted in cases of difference. Excepting the fourth or last group, which is given simply to show that the conditions prevailing on the eastern slope are different from those of the western, it may be seen that the theoretical rain is very nearly the same as the probable mean rain. The instances where the widest variations exist usually can be explained.

In regard to the value of the theoretical rainfall, reference may again be made to the paper by Professor Curtis. He states (p. 8) that the Signal Service, in an investigation of the rainfall on the summit of Mount Washington to determine the local distribution and the average rainfall for the station, placed five gages on the summit of the mountain, one in the center and four to the four points of the compass 75 feet distant from it. It has been known for a long time that a gage placed at an elevation above ground usually recorded less than one placed on the ground below, this difference being caused by wind currents. The increased velocities of the wind around the corners and over the tops of the buildings, hills, or even the gage, tend to increase the slant of the falling rain at those points, and when just past the obstruction, the velocity of the wind being again reduced, the heavier fall of rain will be deposited. In this experiment on Mount Washington observations were made from September 1, 1882, to October 1, 1883. As the measurement of snow was reported as altogether unreliable, it was excluded. In the following table it is shown that the windward gages had received during the period 24.64 inches of rain and the leeward ones 28.43 inches, single storms showing greater variation. The conclusion reached is that precipitation varies materially within distances of only 100 or 200 feet.

The most remarkable feature of the experiment is the different results obtained from gages with 3-inch and 8-inch catchment cups. The gages that were set to the four points of the compass had 3-inch cups and the regular station gage had one 8-inch cup. For the period in question the four exterior gages recorded 45.51.19, 45.40, and 42.63 inches, respectively, while the regular station gage recorded 58.70 inches of rain.

Comparative reading of 3-inch and 8-inch gages in wind.

	Wind velocity in miles per hour.							
	15		40		60		75	
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Diameter of gage	3	8	3	8	3	8	3	
Amount of rain	1.75	1.84	2.77	3.37	1.60	2.44	1.87	
Per cent	100	105	100	122	100	152	100	

n view of these records, which are taken with experimental care, the statement ıld be justified that the "Probable rainfall," as shown in the table on page 351, ees with the "Theoretical rainfall" as closely as it can be measured, the gages ıg of different makes and sizes.

he recorded rainfall of the Cuyamaca gage is probably in excess of the average ı for this elevation and the locality, and it is so considered by engineers in . Diego. The gage is in a narrow valley or canyon, and is probably affected the winds and the topography.

; will be seen that Cisco, with an elevation of 5,934 feet, has a rainfall of 56.28 ıes, while Summit, 13 miles beyond, with an elevation of 7,017, has only 46.99 ıes of rain. It may be that this variation is due to the wind action, especially the snow, which averages each year 31 feet in depth, or to the fact that Sum- is above the plane of maximum rainfall, as mentioned on page 354.

TECOLOTE CREEK.

Discharge measurement of Tecolote Creek, Santa Barbara County.

ıate.	Hydrographer.	Dis-charge.
899.		*Sec.-feet.*
ɜ. —	G. F. Wright	[a] 0.27

[a] Drainage area, 2 square miles.

TEJON CREEK.

ɛe Fort Tejon Creek.

TEJON HOUSE CREEK.

charge measurements of Tejon House Creek, at Tejon Ranch House, Kern County.

ıate.	Hydrographer.	Dis-charge.
395.		*Sec.-feet.*
r. 6	J. B. Lippincott	22.7
:. 3	do	17.2
t. 4	A. P. Davis and J. B. Lippincott	1.57
r. 13	J. B. Lippincott	3.46
396.		
). 1	J. B. Lippincott	7.82
). 2	do	18.3
ıe 4	do	6.09
ıe 5	do	8.31
:. 18	do	3.96
:. 19	do	2.66

TEMESCAL CREEK.

Discharge measurements of Temescal Creek at lower pipe line, Temescal Land and Water Company, Temescal, Riverside County, Cal.

Date.	Hydrographer.	Discharge
1899.		
Jan. 28	F. Rolfe	
Feb. 1	....do	
Feb. 11	....do	
Feb. 15	....do	
Feb. 20	....do	
Mar. 4	....do	
Mar. 12	....do	
Mar. 18	....do	
Mar. 25	....do	
Mar. 31	....do	
Apr. 14	....do	
Apr. 22	....do	
Apr. 29	....do	
May 6	....do	
May 13	....do	
May 30	....do	
June 9	....do	
June 15	....do	
July 4	....do	
July 19	....do	
July 25	....do	
Aug. 5	....do	
Aug. 11	....do	
Aug. 21	....do	

Discharge measurements of Temescal Creek at upper pipe line, Temescal Land and Water Company, Temescal, Riverside County.

Date.	Hydrographer.	Discharge.
1899.		*Sec.-feet.*
Jan. 4	S. G. Dennett	0.99
Jan. 27	F. Rolfe	.74
Feb. 4	do	1.62
Feb. 11	do	.87
Feb. 18	do	3.67
Feb. 24	do	3.37
Mar. 3	do	3.87
Mar. 12	do	5.10
Mar. 16	do	3.56
Mar. 25	do	3.74
Mar. 31	do	4.16
Apr. 14	do	2.93
Apr. 22	do	3.71
Apr. 29	do	3.22
May 6	do	2.80
May 13	do	4.02
May 18	do	4.21
May 30	do	4.01
June 9	do	3.36
June 16	do	3.52
July 10	do	3.21
July 19	do	3.20
July 25	do	3.67
Aug. 11	do	1.48
Aug. 11	do	4.26
Aug. 21	do	3.84

Discharge measurements of Evans ditch, Temescal Creek, Temescal, Riverside County.

Date.	Hydrographer.	Discharge.
1899.		*Sec.-feet.*
July 1		3.75
August		3.00

TORO CANYON.

Discharge measurement of Toro Canyon, Santa Barbara County.

Date.	Hydrographer.	Discharge.
1900.		
June 16	J. B. Lippincott	

TRABUCO CREEK.

Discharge measurement of Trabuco Creek, Orange County.

Date.	Hydrographer.	Discharge.
1899.		
May 24	F. Rolfe	

a Ditch near San Juan Capistrano.

TRUCKEE RIVER.

TRUCKEE RIVER AT TAHOE, CAL.

Truckee River, the natural outlet of Lake Tahoe, leaves the lake at the city of Tahoe. About 500 feet from the lake there is a timber dam across the river, which has been maintained for more than twenty years for the purpose of controlling the discharge from the lake. During the early part of the year 1900 the gates in this dam were kept closed, not being opened until June 17, when a gage was placed in the stream for the purpose of recording the height of the water in the river. The gage is a vertical timber driven into the stream bed at the left bank, about 300 feet below the dam, and is spiked to the root of a tree growing on the bank. The bench mark is cut in the side of the tree, and is 4 feet above gage datum. The measurements are made from a cable and suspended car about one-fourth of a mile below the gage, which was placed as near the city of Tahoe as possible for the convenience of the observer. At the point of measurement the right bank is low, and is subject to overflow at very high stages of the stream, but the left bank is rather high. The channel is nearly straight for a short distance above and below the station, and the bed of the river, which is of gravel and coarse sand, is smooth and stable. The purpose of the station is to ascertain the actual outflow from Lake Tahoe, with a view to determining its value as a storage reservoir.

scharge measurements of Truckee River at outlet of Lake Tahoe, Placer County.

Date.	Hydrographer.	Discharge.
1899.		*Sec.-feet.*
ly 9		136
g. 8		75
g. 14		56
g. 18		49

Discharge measurements of Truckee River at Tahoe, Placer County.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Sec.-feet.*
ne 18	L. H. Taylor	0.75	92
ne 30	do	1.45	2.40
ly 12	do	1.60	2.77
pt. 7	do	1.40	225
t. 23	do	.40	52
t. 23	do	.95	130
t. 23	do	1.15	158
1901.			
pt. 5	C. V. Taylor	1.94	386
pt. 12	do	1.85	356
ov. 11	do	1.57	296
ov. 11	do	1.23	187
ov. 11	do	1.00	141
1902.			
t. 22	E. C. Murphy		320

Discharge measurements of Truckee River one-half mile below Truckee.

Date.	Hydrographer.	Discharge.
1900.		*Sec.-feet.*
ne 8		364
ne 12		264

Estimated monthly discharge of Truckee River at Tahoe.

[Drainage area, 519 square miles.]

Month.	Discharge.			Total discharge.	Run-off	Dep.
	Maximum.	Minimum.	Mean.		Per square mile.	
1895.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	Inc.
July	1,185	442	914	56,200	1.76	
August	441	393	425	26,111	.82	
September	392	357	374	22,244	.72	
October	496	344	415	25,538	.80	
November	471	408	437	26,002	.84	
December	253	246	250	15,388	.48	
1896.						
January	293	244	262	16,102	.50	
February	292	288	290	16,677	.56	
1900.						
March	----------	----------	0	0	0	
April	----------	----------	0	0	0	
May	----------	----------	0	0	0	
June	236	0	52	3,106	.10	
July	260	0	214	13,131	.41	
August	260	211	232	14,261	.45	
September	224	177	196	11,667	.38	
October	177	155	159	9,781	.31	
November	200	0	135	8,047	.26	
December	99	0	81	4,981	.16	
1901.						
January	117	85	102	6,262	.20	
February	117	30	81	4,502	.16	
March	30	30	30	1,845	.06	
April	30	0	9	565	.02	
May	0	0	0	0	0	
June	178	0	30	1,765	.06	
July	293	156	225	13,809	.43	
August	555	293	419	25,760	.81	
September	390	117	326	19,395	.63	
October	308	251	282	17,308	.54	
November	293	189	247	14,678	.48	
December	189	100	111	6,841	.21	
The year	555	0	155	112,730	.30	

Discharge measurements of tributaries of Truckee River at various points.

DEER CREEK, PLACER COUNTY.

Date.	Hydrographer.	Discharge.
1900.		*Sec.-feet.*
June 16		25.2

SQUAW CREEK, PLACER COUNTY.

1900.		
June 5		81.4
June 16		46.0
Sept. 14		2.76

DONNER CREEK, NEAR DONNER LAKE.

1900.		
May 16		127.8
May 29		73.4
July 13		1.09
Aug. 20		69.0
Sept. 13		19.2

DONNER CREEK, NEAR TRUCKEE RIVER.

1900.		
May 21		324.5
June 3		127.0
June 12		98.9
July 13		14.7
1902.		
Oct. 22	E. C. Murphy	3.25

COLD CREEK, NEVADA COUNTY.

1900.		
Sept. 13		1.35

Discharge measurements of tributaries of Truckee River, etc.—Continued.

MARTIS CREEK.

Date.	Hydrographer.	Discharge
1889.		*Sec.-feet*
June 1		19
June 22		7
1900.		
May 21		24.51
June 4		17.52
Sept. 14		8.54

JUNIPER CREEK AT CLINTON.

1889.		
May 30		22
1900.		
June 6		a30
Sept. 15		1.35

JOE GRAY CREEK AT ICELAND.

1889.		
May 31		88
1900.		
May 19		30
July 28		20.5
Sept. 15		12.3

ALDER CREEK AT FLORISTON.

1889.		
May 31		42
1900.		
May 19		a30
July 25		12.6
Sept. 10		10.5

a Estimated.

Discharge measurements of tributaries of Truckee River, etc.—Continued.

DOG VALLEY CREEK AT VERDI.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
1889.		
May 22		7
1900.		
July 26		.40
Sept. 10		.79
1902.		
Oct. 7	D. W. Hays	7.14

TRUCKEE RIVER AT ESSEX, WASHOE COUNTY, NEV.

1889.		
May 20		2,330
May 21		2,570
May 22		2,510
May 29		1,716
June 20		350

SQUAW CREEK ABOUT HALFWAY FROM LAKE TAHOE.

1889.		
June 3		92
June 5		81.4
June 16		46
June 22		15
Sept. 14		2.76

CREEK NEAR TAHOE TOLLGATE.

1889.		
June 3		74

DONNER CREEK.

1889.		
July 3		8
July 6		5
July 11		2
July 16		1
Aug. 7		.9
Aug. 10		.2
Aug. 17		.3

Discharge measurements of tributaries of Truckee River, etc.—Continued.

COLD CREEK THREE-QUARTERS OF A MILE BELOW DONNER LAKE.

Date.	Hydrographer.	Discharge.
1889.		Sec.-ft.
June 28		11
July 3		10
July 6		5
July 11		1
Aug. 7		1
Aug. 10		1
Aug. 17		.7

PROSSER CREEK.

1900.		
June 4		[a]145
July 27		[a]25
Sept. 9		[a]9.5
1902.		
Oct. 23	E. C. Murphy	[b]21.3

LITTLE TRUCKEE RIVER AT BOCA.

1900.		
May 19		[c]6[illegible]
June 6		492
Aug. 16		8.9
Sept. 15		27.[illegible]

HUNTER CREEK.

1900.		
June 7		40.[illegible]
Sept. 12		5.6

INDEPENDENCE CREEK AT INDEPENDENCE LAKE.

1902.		
Oct. 24	E. C. Murphy	.[illegible]

[a] At mouth. [b] At Prosser. [c] Approximate.

Discharge measurements of streams flowing into Lake Tahoe.

WARD CREEK.

Date.	Hydrographer.	Discharge.
1900.		*Sec.-feet.*
May 5		147

BLACKWOOD CREEK.

1900.		
May 6		140

THREE SMALL STREAMS BETWEEN IDLEWILD AND MCKINNEY'S.

1900.		
May 6		[a] 12

M'KINNEY CREEK.

1900.		
May 6		150

GENERAL CREEK.

1900.		
May 7		100

MEIGGS CREEK.

1900.		
May 7		130

FIVE SMALL STREAMS BETWEEN MEEKS CREEK AND EMERALD BAY.

1900.		
May 7–8		[a] 12

EMERALD BAY CREEK.

1900.		
May 8		60

[a] Estimated.

Discharge measurements of streams flowing into Lake Tahoe—Continued.

CASCADE CREEK.

Date.	Hydrographer.	Dis- charge
1900. May 8		

TAYLOR CREEK.

1900. May 8		

UPPER TRUCKEE RIVER.

1900. May 9		

TEN SMALL STREAMS BETWEEN BIJOU AND GLEN BROOK IN NEVADA.

1900. May 10		

a Estimated.

TRUCKEE RIVER AT NEVADA-CALIFORNIA STATE LINE.

This river has its source on the slopes of the Sierra Nevada eastern California and flows northward, entering Lake Tahoe. T lake is at an elevation of 6,225 feet, and is the largest body of fr water in the United States at this considerable altitude. The a of the lake itself is 193 square miles. As the State line betw Nevada and California passes through the lake, a portion of it each State. The outlet of the lake is at Tahoe, Cal., and Truck River from this point has a general northward course, receiving a num ber of important tributaries which contribute to its flow. There a number of lakes at the headwaters of the branch stream, wh have been surveyed and recommended as reservoir sites. The drain area is mapped on the Pyramid Peak, Truckee, Carson, and Mark ville atlas sheets of the United States Geological Survey. The ba is now partially included in the Lake Tahoe forest reserve, set apa by Executive proclamation of April 13, 1899. September 7, 19 station was established on this river by L. H. Taylor, at the S line, 17 miles west of Reno, Nev. The gage is vertical, driven the bed of the river and wired to a granite bowlder. The bench ma

s the top of the rock to which the rod is fastened, and is at an elevation of 10 feet above gage datum. The channel is straight for a hort distance above and below the station. The banks are not liable o overflow. The bed of the river is of gravel and cobbles and is uite stable.

Discharge measurements of Truckee River at State line.

Date.	Hydrographer.	Gage height.	Discharge.
1899.		*Feet.*	*Sec.-feet.*
ept. 7	L. H. Taylor	2.0	303
1900.			
pr. 10	L. H. Taylor	2.9	753
[ay 15	do	4.1	1,493
[ay 22	do	4.3	1,629
une 1	do	3.7	1,112
une 15	do	3.2	901
uly 1	do	2.5	534
uly 14	do	2.5	551
ept. 6	do	2.3	447
ct. 2	do	1.9	318
1901.			
eb. 13	C. V. Taylor	1.5	298
eb. 27	do	4.5	2,474
[ar. 11	do	3.4	1,262
une 9	do	3.9	1,741
uly 13	do	2.6	811
ug. 16	do	2.1	528
ept. 3	do	2.2	570
ept. 14	do	2.0	478
ov. 9	do	1.95	437
ec. 14	do	1.75	353
1902.			
pr. 10	C. V. Taylor	.....	1,492
[ay 10	do	.....	2,384

Estimated monthly discharge of Truckee River at Nevada-California State line

[Drainage area, 955 square miles.]

Month.	Discharge.			Run-off	
	Maximum.	Minimum.	Mean.	Total discharge.	Per square mile.
1899.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*
September 17–30	363	295	303	18,030	0.32
October	632	295	354	21,767	.37
November	1,566	295	581	34,572	.61
December	328	264	295	18,139	.31
1900.					
January	897	295	392	24,103	0.41
February	363	264	318	17,661	.33
March	1,131	295	797	49,006	.83
April	1,409	735	902	53,673	.94
May	1,885	1,196	1,528	93,953	1.60
June	1,409	328	950	56,529	.99
July	533	401	459	28,223	.48
August	486	328	396	24,349	.41
September	486	205	367	21,838	.38
October	897	234	481	29,575	.50
November	897	328	480	28,562	.50
December	1,131	205	407	25,025	.43
The year	1,885	205	623	452,497	.65

TRUCKEE RIVER AT VISTA, NEV.

On the lower courses of this river there are considerable stretches of irrigable land which, however, have not yet been developed to the fullest extent. The drainage basin is peculiar in that its mountainous collecting area is located in the State of California, while the lands which can be irrigated are situated in Nevada. This may lead in the future to certain legal difficulties, but not to the extent that it would if there were agricultural lands in both States. Truckee River, after entering Nevada, flows in a general easterly and then northerly direction, emptying into Pyramid Lake. The drainage area is mapped on the Pyramid Peak, Truckee, Markleeville, Carson, Reno, and Wadsworth atlas sheets of the United States Geological Survey. The station at Vista, Nev., was established August 18, 1899, by L. H. Taylor, and is located 7 miles east of Reno. The rod is spiked to posts driven into the bed of the river. The bench mark is on a bluff rock 500 feet east of the gage, and is at an elevation of 17.50 fe

above gage datum. A new bench mark was established March 14, 1901, on the top of a 2 by 2 inch plug driven 2 feet into the ground at the upper end of the inclined gage on the left bank. Its elevation is 4.60 feet above the datum of the gage. Both banks are high and not liable to overflow. The bed is rocky and not subject to change.

Discharge measurements of Truckee River at Vista, Nev.

[L. H. Taylor, hydrographer.]

Date.	Gage height.	Discharge.
1899.	*Feet.*	*Sec.-feet.*
September 5	2.0	105
October 28	2.75	477
1900.		
April 25	3.30	7.57
May 14	3.80	9.89
May 23	4.30	1,326
June 9	3.80	967
June 14	4.10	1,150
June 19	2.90	471
June 28	2.70	372
July 2	2.20	207
July 10	2.05	138
July 24	2.00	99
August 22	2.30	198
September 28	2.25	226
1901.		
February 22	6.35	3,077
March 14	3.85	[a]899
March 20	3.88	[a]911
June 21	4.10	1,165
July 12	2.70	417
August 15	2.20	198
September 2	2.50	325
September 14	2.40	276
November 13	3.05	584
December 15	2.78	448

[a] Results too small.

Estimated monthly discharge of Truckee River at Vista, Nev.

[Drainage area 1,519 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1890.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
April			4,496			
May			5,990			
June			4,162			
July			2,198			
August			952			
September			682			
October			742			
November			765			
December			750			
1891.						
January			[a]700			
February			[a]650			
March			[a]650			
April			1,523			
May			2,765			
June			1,905			
July			945			
August			485			
September			558			
October			561			
November			503			
December			508			
The year			980			
1892.						
January			593			
February			505			
March			723			
April			854			
May			937			

[a] Estimated.

Estimated monthly discharge of Truckee River at Vista, Nev.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1899.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
August 18–31			114			
September	188	74	152	9,073	0.10	0.11
October	1,066	144	378	23,251	.25	.29
November	1,123	355	516	30,713	.34	.38
December	709	331	456	28,019	.30	.35
1900.						
January	1,210	380	479	29,445	0.32	0.36
February	529	380	426	23,671	.28	.29
March	1,094	454	857	52,668	.56	.65
April	1,239	479	756	44,982	.50	.56
May	1,477	843	1,257	77,289	.83	.95
June	1,239	259	709	42,201	.47	.52
July	307	74	110	6,746	.07	.08
August	283	61	122	7,513	.08	.09
September	283	105	192	11,449	.13	.14
October	1,123	258	430	26,456	.28	.33
November	1,298	331	566	33,660	.37	.42
December	1,268	429	554	34,049	.36	.42
The year	1,477	61	538	390,129	.35	4.81
1901.						
January	1,505	418	661	40,644	0.44	0.50
February	4,213	418	1,486	82,529	.98	1.02
March	2,209	938	1,328	81,657	.87	1.01
April	1,942	747	1,380	82,117	.91	1.01
May	4,213	1,410	2,145	131,894	1.42	1.63
June	1,942	854	1,263	75,155	.83	.93
July	995	146	425	26,133	.28	.32
August	492	128	315	19,369	.21	.23
September	467	251	329	19,577	.22	.24
October	720	370	477	29,330	.31	.36
November	882	467	557	33,144	.37	.41
December	1,287	322	510	31,357	.34	.39
The year	4,213	128	906	652,906	.60	8.05

TULE RIVER.

Tule River drains a portion of the western slope of the Sierra Nevada. Its watershed is somewhat less productive of run-off than that of Kaweah River, which joins it on the north, and much less elevated and snow covered than Kings River basin.

The waters of this stream are all appropriated during the irrigation season, and a portion of them are used in irrigating valuable orange lands in the vicinity of Porterville, Cal.

The gaging station is located about 8 miles east of Porterville, at a point just below the wagon bridge near the McFarland ranch, and about 1 mile above the mouth of the South Fork of Tule River. The station was established April 18, 1901. The gage rod is situated on the right bank of the river, 100 feet below the bridge. The zero of the gage is 8 feet below a spike driven into a large cottonwood tree. The area of the watershed above the gaging station is approximately 300 square miles.

Discharge measurements of Tule River.

Date.	Hydrographer.	Discharge.	Location.
		Sec.-feet.	
Nov. 18, 1895	J. B. Lippincott	32.1	In Pioneer canal.
Nov. 18, 1895	do	28.4	River below canal.
	Total	60.5	
Sept. 2, 1900	S. G. Bennett	4.3	Canal.
Sept. 2, 1900	do	4.7	River.
	Total	9.0	
Oct. 3, 1902	L. M. Lawson	7.0	Canal.
Oct. 3, 1902	do	8.2	River.
	Total	15.2	
Oct. 3, 1902	L. M. Lawson	14.0	At headworks, Pioneer canal
Oct. 3, 1902	do	7.0	1 mile below intake, Pioneer canal.
July 19, 1901	A. E. Chandler	19.8	Below intake of Pioneer canal.
Oct. 3, 1902	L. M. Lawson	8.2	
May 23, 1901	W. N. Frickstad	152.0	Rockford Bridge, 6 miles west of Porterville.
June 28, 1901	A. E. Chandler	164.6	14 miles above Porterville.

Discharge measurements of Tule River, Tulare County.

Date.	Hydrographer.	Discharge.	Location.
1902.		*Sec.-feet.*	
ept. 30	E. T. Perkins	2.6	Middle Fork, trail crossing below location of Doyle's headworks.
ept. 30	do	14.0	Middle Fork 100 yards above head Doyles ditch.
ct. 1	do	24.0	Middle Fork at trail crossing near junction with East Fork.
ct. 1	do	15.0	East Fork 100 yards above mouth.
ct. 3	do	10.0	East Fork at trail crossing Nelsons to Indian Reservation.
ct. 2	do	3.0	South Fork 6 miles below Indian Agency.
ct. 3	do	3.2	South Fork near Tom Wheaton's ranch.
ct. 3	L. M. Lawson	(a)	South Fork at junction of North Fork.
ct. 3	do	4.0	Pioneer canal at Porterville.

a Dry.

ischarge measurements of Tule River at McFarlands Bridge, above mouth of South Fork.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Sec.-feet.*
pr. 18	S. G. Bennett	2.5	233
lay 22	J. B. Lippincott	2.85	338
une 10	do	2.65	311
une 28	A. E. Chandler	2.00	148
uly 29	S. G. Bennett	1.23	30
ct. 18	do	1.00	18
ec. 9	do	1.44	58
1902.			
eb. 5	do	1.33	43
lar. 8	do	2.2	156
lay 15	do	3.03	371
ct. 2	L. M. Lawson	.92	15

Discharge measurements of Lower Tule canal at Tulare Lake.

Date.	Hydrographer.	Dis-
1901.		
June 24	A. E. Chandler	

Discharge measurements of Pioneer canal, Tulare County.

Date.	Hydrographer.	Discharge.	Location.
1898.		*Sec.-feet.*	
Sept. 1	P. M. Baier	6.0	
1899.			
Sept. 5	S. G. Bennett	13.1	200 feet below headworks.
Sept. 5	do	8.43	1 mile below headworks.
Sept. 5	do	7.06	2 miles below headworks.
1902.			
Oct. 3	L. M. Lawson	14.0	At headworks.
Oct. 3	do	7.0	1 mile below headworks.

Discharge measurements of South Fork of Tule River at mouth, 7 miles east of Porterville, Tulare County.

Date.	Hydrographer.	Dis-
1901.		
June 10	J. B. Lippincott	
July 29	S. G. Bennett	
1902.		
May 15	do	

[a] Estimated.

Estimated monthly discharge of Tule River at Porterville.[a]

[Drainage area, 437 square miles.]

Month.	Discharge.			Total discharge	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1878.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
vember			131	7,795	0.30	0.33
cember			131	8,055	.30	.35
1879.						
nuary			57	3,505	0.13	0.15
bruary			87	4,832	.20	.21
arch			61	3,751	.14	.16
ril			118	7,021	.27	.30
ay			105	6,456	.24	.28
ne			350	20,826	.80	.89
ly			35	2,152	.08	.09
gust			26	1,599	.06	.07
ptember			26	1,547	.06	.07
tober			74	4,550	.17	.20
vember			140	8,330	.32	.36
cember			271	16,663	.62	.71
The year			113	81,232	.25	3.49
1880.						
nuary			577	35,478	1.32	1.52
bruary			1,040	59,821	2.38	2.57
arch			1,079	66,344	2.47	2.84
ril			1,289	76,701	2.95	3.28
ay			1,040	63,946	2.38	2.75
ne			721	42,902	1.65	1.84
ly			350	21,520	.80	.92
gust			87	5,349	.20	.23
ptember			44	2,618	.10	.11
tober			44	2,705	.10	.12
vember			87	5,177	.20	.22
cember			219	13,466	.50	.58
The year			548	396,027	1.25	16.98

[a] Authority, California State engineering department from November, 1878, to October, 1884.

Estimated monthly discharge of Tule River at Porterville—Continued.

Month.	Discharge.			Total discharge.	Run-off	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1881.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January			219	13,466	0.50	
February			437	24,270	1.00	
March			437	26,870	1.00	
April			874	52,006	2.00	
May			874	53,740	2.00	
June			437	26,003	1.00	
July			219	13,466	.50	
August			175	10,760	.40	
September			87	5,177	.20	
October			66	4,058	.15	
November			57	3,392	.13	
December			66	4,058	.15	
The year			329	237,266	.75	
1882.						
January			87	5,349	0.20	
February			109	6,053	.25	
March			306	18,815	.70	
April			660	39,273	1.51	
May			1,748	107,480	4.00	
June			660	39,273	1.51	
July			437	26,870	1.00	
August			131	8,055	.30	
September			66	3,927	.15	
October			44	2,705	.10	
November			66	3,927	.15	
December			66	4,058	.15	
The year			365	265,785	.83	

Estimated monthly discharge of Tule River at Porterville—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1883.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
nuary			87	5,349	0.20	0.23
bruary			87	4,832	.20	.21
arch			437	26,870	1.00	1.15
ril			656	39,034	1.50	1.67
ay			874	53,740	2.00	2.31
ne			874	52,006	2.00	2.23
ly			350	21,521	.80	.92
igust			87	5,349	.20	.23
ptember			66	3,927	.15	.17
tober			44	2,705	.10	.12
vember			44	2,618	.10	.11
cember			66	4,058	.15	.17
The year			306	222,009	.70	9.52
1884.						
nuary			262	16,109	0.60	0.69
bruary			1,748	100,546	4.00	4.31
arch			1,311	80,610	3.00	3.46
pril			874	52,006	2.00	2.23
ay			2,185	134,350	5.00	5.76
ne			3,059	182,023	7.00	7.81
ly			2,622	161,220	6.00	6.92
igust			874	53,740	2.00	2.31
ptember			350	20,826	.80	.89
tober			175	10,760	.40	.46

Estimated monthly discharge of Tule River at McFarlands Bridge near Porterville, Tulare County.

[Drainage area, 437 square miles.]

Month.	Discharge.			Total discharge.	Run-off
	Maximum.	Minimum.	Mean.		Per square mile.
1901.	*Sec.-feet.*	*Sec.-feet*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet*
May	875	298	418	25,702	0.96
June	408	126	240	14,281	.55
July	126	30	61	3,751	.14
August	30	18	19	1,168	.04
September	23	10	17	1,012	.04
October	109	18	29	1,783	.07
November	71	35	43	2,559	.10
December	64	39	50	3,074	.11
1902.					
January	51	34	45	2,767	.10
February	1,415	45	159	8,830	.36
March	2,735	144	362	22,259	.83
April	4,615	249	571	33,977	1.31
May	408	273	343	21,090	.79
June	324	78	190	11,306	.43
July	78	26	43	2,644	.10
August	33	18	21	1,291	.05
September	17	14	15	893	.03
October	93	14	24	1,476	.05
November	144	27	50	2,975	.11
December	204	45	62	3,812	.14
The year	4,615	14	157	113,320	.36

TUMITUS CREEK.

Discharge measurement of Tumitus Creek, San Mateo County.

Date.	Hydrographer.	Discharge.
1893.		Sec.-ft.
Oct. 17	W. W. Brier	2

TUNIS CREEK.

Discharge measurement of Tunis Creek, Kern County.

Date.	Hydrographer.	Discharge.
896.		*Sec.-feet.*
ne 4	J. B. Lippincott	1.98
c. 15	do	.7

[a] At mouth.

TUOLUMNE RIVER.

HETCH HETCHY DAM SITE, HETCH HETCHY VALLEY.

The entire drainage of Tuolumne River above Lagrange is about 500 square miles, some 400 square miles of which lie above the Hetch Hetchy dam site, the elevation of which is 3,630 feet above sea level. This upper drainage area consists of high granite mountains culminating in Mount Dana, Mount Gibbs, and Mount Lyell. A gaging station was established at this point May 30, 1901, by J. B. Lippincott, for the city of San Francisco.

For detailed description of Hetch Hetchy reservoir site see Twenty-first Annual Report of U. S. Geological Survey, Part IV, page 450.

Discharge measurements of Tuolumne River, Hetch Hetchy Valley, Tuolumne County.

Date.	Hydrographer.	Gage height.	Discharge.	Location.
1899.		*Feet.*	*Sec.-feet.*	
ly 31	H. Ramel		238.0	
ug. 5	do		230.0	
ug. 12	do		131.0	
ug. 19	do		101.0	
ug. 23	do		69.0	
1901.				
ug. 13	J. B. Lippincott and W. W. Cockins, jr.		472.0	Ford in Hetch Hetchy Valley.
ug. 29	W. W. Cockins, jr	12.93	190.5	Do.
pt. 5	do	12.65	155.7	Do.
pt. 14	do	12.42	77.5	Do.
ct. 5	do	12.92	115.6	Do.
ct. 11	do	12.60	88.0	Do.
ug. 25	do	13.28	231.3	1,000 feet above dam site.
ept. 28	do	13.11	144.7	Do.
1902.				
ug. 29	E. T. Perkins		66.0	Upper end Hetch Hetchy Valley.

Discharge measurements of Tuolumne River at Hetch Hetchy dam site.

Date.	Hydrographer.	Gage height.	Dis-
1901.		*Feet.*	
June 29	C. A. Miller and W. W. Cockins, jr	36.00	
July 4	C. A. Miller	30.00	
July 12	do	26.10	
July 21	do	24.17	
July 29	W. W. Cockins, jr	21.50	
Aug. 2	do	20.33	
Aug. 13	J. B. Lippincott	15.70	
Sept. 20	W. W. Cockins, jr	12.32	

Discharge measurements of Tuolumne River at old bridge above Rancheria (or Tuolumne County.

Date.	Hydrographer.	Gage height.	Dis-
1901.		*Feet.*	
July 13	C. A. Miller		
Aug. 26	W. W. Cockins, jr		
Sept. 28	do		
Oct. 11	do		

Discharge measurements of Rancheria Creek (tributary to Tuolumne River) at old sheep bridge, Tuolumne County.

Date.	Hydrographer.	Gage height.	Dis-
1901.		*Feet.*	
Aug. 26	W. W. Cockins, jr		
1902.			
Aug. 29	E. T. Perkins		

[a] At head of falls.

CHERRY RIVER AT ELEANOR TRAIL CROSSING.

Cherry River is a tributary of the Tuolumne and enters that stream 12½ miles below Hetch Hetchy Valley. The area drained is 13[illegible] miles.

A gaging station was established at the point where Eleanor trail crosses the river, on May 26, 1901, by J. B. Lippincott, for the city of San Francisco.

'ischarge measurements of Cherry Creek, a tributary of Tuolumne River, at Eleanor trail crossing.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Sec.-feet.*
ıly 8	C. A. Miller	11.40	915.0
ıly 17	do	10.40	510.0
ug. 9	W. W. Cockins, jr	8.75	112.0
ug. 19	do	9.10	132.0
ug. 20	do	8.40	107.0
ug. 24	do	8.10	43.0
ept. 1	do	7.80	17.5
ept. 7	do	7.70	6.1
ept. 17	do	7.00	4.3
ept. 22	do	7.06	4.5
ept. 26	do	9.05	141.0
ct. 3	do	8.96	120.0
ct. 10	do	8.00	43.0
1902.			
ug. 30	E. T. Perkins		[a]4.4
ug. 30	do		6.0

[a] 1,500 feet below trail crossing.

ELEANOR CREEK AT ELEANOR TRAIL CROSSING.

Eleanor Creek is a tributary of Cherry River and enters that stream miles above its mouth. The elevation of the outlet of Lake Eleanor 4,655 feet above sea level. The drainage area above the gaging ation is 81 square miles, and consists of high granite mountains cul- inating in Richardson Peak, elevation 9,845 feet; Haystack Peak, levation 9,966 feet; and an unnamed peak, elevation 10,510 feet. he average elevation of the drainage basin is probably 7,500 feet.

A gaging station was established at the outlet of Lake Eleanor June , 1901, by J. B. Lippincott, for the city of San Francisco.

For a detailed description of Lake Eleanor reservoir site see Thir- enth Annual Report of the U. S. Geological Survey, Part III, page 02.

Discharge measurements of Eleanor Creek at inlet to Lake Eleanor, Tuolumne County.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	
June 11	C. A. Miller		
Do	do		
	Total		
July 16	C. A. Miller		
Do	do		
	Total		
Aug. 18	W. W. Cockins, jr		
Do	do		
	Total		
Aug. 27	W. W. Cockins, jr		
Do	do		
	Total		
Oct. 1	W. W. Cockins, jr		
Do	do		
	Total		

[a] West Branch. [b] East Branch.

Discharge measurements of Eleanor Creek at outlet of Lake Eleanor, Tuolumne County.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	
June 10	C. A. Miller	8.67	
June 22	do	9.76	
July 8	J. B. Lippincott	8.57	
July 16	C. A. Miller	7.92	
July 18	do	7.80	
July 27	W. W. Cockins, jr	7.45	
Aug. 3	do	7.10	
Aug. 10	do	6.93	
Aug. 17	do	6.48	
Aug. 19	do	6.68	
Aug. 23	do	6.47	
Aug. 27	do	6.26	
Aug. 30	do	6.05	

Discharge measurements of Eleanor Creek, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Sec.-feet.*
ept. 6	W. W. Cockins, jr	5.90	6.22
ept. 14	do	5.70	4.08
ept. 21	do	5.72	5.02
ept. 26	do	5.85	5.77
ct. 3	do	6.40	34.5
ct. 10	do	6.21	21.2

Discharge measurements of Tuolumne River.

Date.	Hydrographer.	Discharge.	Location.
1902.		*Sec.-feet.*	
ug. 22	E. T. Perkins	6.0	North Fork at headworks, Goldwin Mining Co.'s canal.
ug. 27	do	152.0	¼ mile above junction of South Fork.
Do	do	20.0	South Fork, ¼ mile above junction of main river.
ug. 29	do	.5	Tiltill Creek at trail crossing.
Do	do	89.0	Lower end Hetch Hetchy Valley.
ug. 31	do	3.0	100 yards below bridge, Middle Fork.
ept. 2	do	23.0	Above falls, lower end Tuolumne Meadows.
ug. 25	do	22.0	Jacksonville.
ug. 26	do	159.0	Ward's ferry.
ug. 28	L. M. Lawson	150.0	Jacksonville, Tuolumne County.
ug. 27	do	4.0	Mining Company's ditch at Lagrange, Stanislaus County.
Do	do	105.0	Turlock canal.

Discharge measurements of Frog Creek at inlet Eleanor Lake, Tuolumne County, Cal.

Date.	Hydrographer.	Discharge.	Location.
1901.		*Sec.-feet.*	
une 12	C. A. Miller	116.0	
uly 17	do	33.	
ug. 18	W. W, Cockins, jr.	5.7	
ug. 27	do	1.0	
ct. 1	do	4.9	

Discharge measurements of Falls Creek at Lake Vernon (upper end), Tuolumne County, Cal.

Date.	Hydrographer.	Discharge.	Location.
1901.		*Sec.-feet.*	
Aug. 12	J. B. Lippincott	36.5	
Sept. 5	W. W. Cockins, jr.	9.8	Tiltill trail crossing.
Sept. 19	do	3.0	Do.
Oct. 4	do	16.0	Do.
1902.			
Aug. 29	E. T. Perkins	4.0	100 yards above junction with Tuolumne

TUOLUMNE RIVER AT LAGRANGE.

This river rises on the western slope of the Sierra Nevada in California and drains the country located between Stanislaus River on the north and Merced River on the South. The northern half of the Yosemite National Park includes a portion of its drainage basin. The river is fed largely from small mountain lakes occurring high in the drainage basin, where snow remains on the mountain slopes throughout the year. The stream has a heavy fall, and the opportunities for power development are numerous. There are also a number of reservoir sites in the basin where water could be stored during the irrigation season. The gaging station, established August 29, 1902, is located at the wagon bridge in the town of Lagrange, Cal. The gage is vertical and is bolted to the right-hand pier of the bridge. The bench mark is a nail driven into the bottom of the west post of the fifth bent south of the south iron cylinder, and is 15.31 feet above gage datum. The station is located below the high dam of the Turlock and Modesto irrigation districts, and also below the head of the canal of the Lagrange Hydraulic Mining Company. This latter canal diverts water from the left bank of the river 14 miles above Lagrange dam. This water is used for hydraulic mining, and partly returned above the gaging station, depending on the convenience of the miners. During 1898 water was first turned down the Turlock Canal in small quantity, and was used for puddling the banks and testing dams of certain reservoirs. Whenever measurements at the gaging station were made, the Turlock Canal and the mining company's canal were also measured. The channel at the station, both above and below the bridge, is straight for several hundred feet, and the velocity of the stream is rather uniform. Both banks are high and not subject to overflow.

Discharge measurements of Tuolumne River at Lagrange, Stanislaus County.

Date.	Hydrographer.	Gage height.	Discharge.
1895.		*Feet.*	*Sec.-feet.*
ug. 29	J. B. Lippincott	4.4	299.00
ept. 14	do	5.8	1,824.00
ov. 28	do	4.2	129.00
1896.			
pr. 15	J. A. Vogleson	6.95	4,236.00
ay 4	H. Crowe	7.0	4,004.00
une 17	do	9.3	8,274.00
ept. 4	do	4.9	671.00
ct. 30	J. B. Lippincott	4.45	361.00
1897.			
eb. 15	do	5.8	1,864.00
ay 29	do	9.25	11,594.00
uly 12	A. Q. Campbell	5.7	1,839.00
ept. 7	do	4.0	95.00
ct. 30	do	4.73	534.00
ec. 20	J. B. Lippincott	4.85	614.00
1898.			
ay 31	do	5.9	1,887.00
pr. 18	do	7.18	5,762.00
uly 30	do	3.95	103.00
ct. 7	do	4.2	[a] 30.00 [b] 24.00 [c] 83.00
	Total		137.00
1899.			
ar. 3	J. B. Lippincott	5.0	774.00
pr. 20	S. G. Bennett	7.55	5,712.00
pr. 21	do	7.85	6,943.00
ay 19	do	6.72	3,616.00
une 6	do	8.47	8,964.00
une 29	do	6.15	2,347.00
ug. 3	do	3.70	23.00
ept. 11	do	3.58	[c] 12.00 [a] 29.00 [b] 24.00
	Total		65.00

[a] Turlock Canal. [b] La Grange Ditch and Hydraulic Mining Company's Canal. [c] River.

Discharge measurements of Tuolumne River, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Sec.-feet.*
1900.			
April 5	S. G. Bennett	6.08	[illegible]
	Total		2,439.0
May 20	S. G. Bennett	8.4	8,720.0
June 22	do	7.09	[illegible]
	Total		4,65[illegible]
Aug. 11	S. G. Bennett		[illegible]
	Total		146.0
Sept. 8	S. G. Bennett		[illegible]
	Total		54.[illegible]
Dec. 27	S. G. Bennett	5.32	984.[illegible]
1901.			
Jan. 29	S. G. Bennett	5.75	1,4[illegible]
Apr. 7	do	6.10	[illegible]
	Total		2,38[illegible]
June 12	J. B. Lippincott	7.63	6,4[illegible]
Aug. 2	S. G. Bennett	5.45	1,3[illegible]
Aug. 31	do	4.30	24[illegible]
1902.			
Mar. 6	S. G. Bennett	6.00	[illegible]
	Total		2,45[illegible]

[a] River. [b] Turlock Canal. [c] La Grange Ditch and Hydraulic Mining Company's [illegible]

Discharge measurements of Tuolumne River, etc.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.	*Sec.-feet.*
May 13	S. G. Bennett	8.35	[a] 9,476.00
			[b] 253.00
			[c] 5.00
	Total		9,734.00
Aug. 27	L. M. Lawson		[a] 15.00
			[b] 105.00
			[c] 4.00
	Total		124.00

[a] River. [b] Turlock Canal. [c] La Grange Ditch and Hydraulic Mining Company's canal.

Estimated monthly discharge of Tuolumne River exclusive of canals at Lagrange, Stanislaus County.

[Drainage area 1,501 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1895.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
August						
September	2,182	78	263	15,635	0.18	0.20
October	299	78	134	8,231	.09	.10
November	129	112	113	6,698	.08	.08
December	1,004	129	270	16,614	.18	.21
1896.						
January	7,610	350	2,312	142,159	1.54	1.78
February	1,780	1,080	1,164	66,954	.78	.84
March	11,798	1,006	2,725	167,578	1.82	2.10
April	7,990	2,670	3,522	209,574	2.34	2.60
May	10,100	2,670	4,429	272,371	2.95	3.40
June	9,320	5,140	7,692	457,705	5.13	5.74
July	5,330	960	3,003	184,677	2.00	2.31
August	3,050	227	485	29,828	.32	.37
September	1,620	132	432	25,742	.29	.32
October	350	75	120	7,366	.08	.09
November	5,710	227	1,135	67,543	.75	.83
December	3,620	670	1,083	66,603	.72	.83
The year [a]	11,798	75	2,342	1,698,100	1.56	21.21

[a] During 1896 there was no water in the Turlock Canal, and the Lagrange Ditch and Hydraulic Mining Company's Canal was flowing 32 second-feet approximately. The Lagrange Ditch and Hydraulic Mining Company's Canal was flowing approximately 35 second-feet during 1895.

Estimated monthly discharge of Tuolumne River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1897.	*Sec.-feet.*	*Sec. feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	3,930	660	1,231	75,692	0.82	.94
February	13,200	1,840	5,172	287,238	3.45	3.79
March	10,800	2,500	4,032	247,920	2.69	3.10
April	13,500	3,280	7,735	460,263	5.15	5.75
May	14,700	9,600	11,923	733,121	7.94	9.15
June	9,300	2,500	5,673	337,566	3.78	4.22
July	4,840	480	2,181	134,105	1.45	1.67
August	570	76	237	14,573	.16	.18
September	140	28	86	5,117	.06	.07
October	750	76	222	13,650	.15	.17
November	3,540	260	768	45,699	.51	.57
December	4,060	570	1,104	67,883	.74	.85
The year [a]	14,700	28	3,364	2,422,827	2.24	30.19
1898.						
January	750	300	454	27,916	0.30	.35
February	2,500	300	900	49,983	.60	.62
March	2,060	750	1,224	75,261	.82	.94
April	7,800	1,270	4,014	238,849	2.67	2.98
May	6,960	2,280	4,620	284,075	3.08	3.55
June	3,280	750	2,247	133,705	1.50	1.67
July	750	88	277	17,032	.19	.21
August	100	76	85	5,226	.06	.07
September	88	0	20	1,190	.01	
October	88	32	52	3,197	.03	
November	82	16	39	2,321	.03	
December	2,060	32	256	15,741	.17	.20
The year [b]	7,800	0	1,182	854,496	.79	10.72

[a] There was no discharge from the Turlock Canal during the year 1897 past the Lagrange gaging station; it was wasted into the river above. For flow of the Lagrange Ditch and Hydraulic Mining Company's Canal, see special measurements of that canal.

[b] During the year 1898 the Turlock Canal was not discharging any material amount of water past the Lagrange gaging station, and the Lagrange Ditch and Hydraulic Mining Company's Canal was carrying about 24 second-feet.

Estimated monthly discharge of Tuolumne River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1899.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
anuary	1,940	110	487	29,945	0.32	0.37
ebruary	1,440	410	740	41,098	.49	.51
larch	21,800	570	3,616	222,341	2.41	2.78
pril	8,040	2,285	5,193	309,004	3.46	3.86
lay	8,680	2,080	4,513	277,495	3.01	3.47
une	9,960	2,285	6,660	360,594	4.04	4.51
uly	2,490	330	1,010	62,103	.67	.77
ugust	570	45	145	8,916	.10	.11
eptember	45	15	33	1,964	.02	.02
ctober	2,285	5	505	31,051	.34	.39
ovember	6,400	660	2,428	144,476	1.62	1.81
ecember	8,040	850	3,047	187,354	2.03	2.04
The year[a]	21,800	5	2,315	1,676,341	1.54	20.64
1900.						
anuary	13,160	1,060	2,384	146,586	1.59	1.83
ebruary	1,300	750	967	53,704	.64	.67
March	3,100	950	2,343	144,065	1.56	1.80
April	4,320	1,440	2,389	142,155	1.59	1.77
May	9,320	3,100	6,796	417,870	4.53	5.23
June	8,680	2,285	5,291	314,836	3.53	3.94
July	1,740	140	694	42,672	.46	.53
August	140	0	43	2,644	.03	.03
September	110	0	11	655	.01	.01
October	5,760	35	1,228	75,507	.82	.94
November	14,440	410	2,536	150,902	1.69	1.89
December	2,080	850	1,332	81,902	.89	1.02
The year[b]	14,440	0	2,160	1,573,498	1.45	19.66

[a] For record of discharge of Turlock Canal beginning July 1, 1899, see Turlock Canal. Lagrange Ditch and Hydraulic Mining Company's Canal discharged about 24 second-feet during the year.

[b] For discharge of Turlock Canal for 1900 see Turlock Canal. Lagrange Ditch and Hydraulic Mining Company's Canal, January 1 to June 23, 24 second-feet; from June 24 to October 20, 12 second-feet; and from October 21 to December 31, 10 second-feet.

Estimated monthly discharge of Tuolumne River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	18,280	560	3,351	206,145	2.23	2.57
February	19,240	1,440	7,204	400,090	4.80	5.00
March	7,080	2,080	3,720	228,733	2.48	2.86
April	7,080	1,740	3,961	235,696	2.64	2.95
May	13,160	4,075	8,036	494,114	5.35	6.17
June	13,160	4,900	9,387	558,566	6.25	6.97
July	9,960	1,440	3,701	227,566	2.47	2.85
August	2,080	200	784	48,206	.52	.60
September	350	55	175	10,413	.12	.13
October	1,590	0	211	12,974	.14	.16
November	1,300	300	574	34,155	.38	.43
December	5,800	200	1,339	82,332	.89	1.03
The year [a]	19,240	0	3,537	2,538,990	2.37	32.72
1902.						
January	850	200	352	21,644	0.23	0.27
February	6,780	250	1,443	80,140	.96	1.00
March	5,810	1,180	2,103	129,308	1.40	1.61
April	12,630	1,320	4,735	281,752	3.15	3.51
May	11,360	2,470	6,334	389,462	4.22	4.87
June	11,360	3,140	6,519	387,907	4.34	4.84
July	2,690	350	998	61,365	.66	.76
August	300	0	91	5,595	.06	.07
September	200	35	89	5,296	.06	.07
October	560	15	113	6,948	.08	.09
November	2,690	250	676	40,225	.45	.50
December	2,690	350	809	49,743	.54	.62
The year	12,630	0	2,022	1,459,385	1.35	18.31

[a] Record for Turlock Canal for 1901 is incomplete. The Lagrange Ditch and Hydraulic Mining Company's Canal discharged from January 1 to March 31, 10 second-feet; April 1 to July 7 second-feet, and flow was not material after that.

scharge measurements of Lagrange Ditch and Hydraulic Mining Company's Canal.

Date.	Hydrographer.	Discharge.
1896.		*Sec.-feet.*
ɔr. 15	J. A. Vogleson	32.0
1897.		
ıy 29	J. B. Lippincott	22.0
t. 30	A. Q. Campbell	6.2
c. 20	J. B. Lippincott	24.0
1898.		
ɔr. 18	J. B. Lippincott	[a] 30.0
ay 31	....do	26.0
ly 30	....do	24.0
t. 7	....do	24.0
1899.		
ar. 3	J. B. Lippincott	24.0
pr. 21	S. G. Bennett	23.5
ne 29	....do	24.0
ug. 3	....do	24.0
pt. 11	....do	24.0
1900.		
pr. 5	S. G. Bennnett	24.0
ne 22	....do	12.5
ug. 11	....do	12.0
1901.		
pr. 7	S. G. Bennett	7.2
ug. 31	....do	4.5

[a] Estimated.

Discharge measurements of Turlock canal, Lagrange, Stanislaus County.

Date.	Hydrographer.	Gage height.	Discharge
1897.		*Feet.*	
Sept. 7	A. Q. Campbell		
1898.			
Oct. 7	J. B. Lippincott		
1899.			
Apr. 21	S. G. Bennett		
May 20	do		
June 6	do		
June 29	do	0.75	
Aug. 4	do	1.70	
Sept. 9	do	1.0	
1900.			
Apr. 6	S. G. Bennett	2.0	
June 22	do	.50	
Aug. 11	do	1.90	
Sept. 8	do	1.15	
1901.			
Aug. 31	S. G. Bennett	.0	
1902.			
May 13	S. G. Bennett	2.92	
July 23	do	3.0	
Aug. 27	L. M. Lawson	2.6	

stimated monthly discharge of Turlock canal at Lagrange, Stanislaus County.

Month.	Discharge.		
	Maximum.	Minimum.	Mean.
1899.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*
ıly	48	1	11
ugust	86	1	55
eptember	34	8	19
ctober	10	1	7
ovember	3	0	1
ecember	0	0	0
1900.			
ınuary	0	0	0
ebruary	133	28	62
[arch	133	64	84
pril	133	0	90
[ay	133	133	133
une	133	9	71
uly	133	0	120
ugust	133	0	57
eptember	36	0	26
ctober	0	0	0
[ovember	0	0	0
ecember	0	0	0
The year	133	0	54
1902.			
anuary	0	0	0
'ebruary	0	0	0
[arch	286	0	187
pril	360	0	268
[ay	380	0	325
une	420	400	406
uly	460	215	405
ugust	367	105	287
eptember	47	0	0
)ctober	0	0	0
Jovember	0	0	0
)ecember	0	0	0
The year	460	0	156

Discharge measurements of Tuolumne River at Modesto, Stanislaus County.

Date.	Hydrographer.	Gage height.	Dis-charge.
1895.		*Feet.*	
Jan. 8	J. B. Lippincott	7.7	
Mar. 21	do	6.75	
May 1	do	10.25	
May 2	do	12.9	
June 27	do	13.0	
Aug. 27	A. P. Davis	4.0	
Nov. 30	J. B. Lippincott	3.42	
1896.			
Apr. 14	J. A. Vogleson	7.9	
July 4	C. C. Babb	9.6	
Sept. 5	H. Crowe	4.5	
Oct. 31	J. B. Lippincott	3.92	

Estimated monthly discharge of Tuolumne River at Modesto, Stanislaus County.

[Drainage area, 1,635 square miles.]

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1878.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
November			65	3,868	0.04	
December			65	3,996	.04	
1879.						
January			478	29,391	0.29	
February	14,230		1,876	104,187	1.15	
March	6,920	830	2,797	171,980	1.71	
April	8,360	2,350	4,456	265,150	2.73	
May	8,230	2,740	5,086	312,726	3.11	
June	11,870	4,670	7,061	420,158	4.32	
July	4,670	570	1,977	121,560	1.21	
August			183	11,252	.11	
September			39	2,321	.02	
October			30	1,844	.02	
November			101	6,010	.06	
December	4,790	140	903	55,523	.55	
The year			2,082	1,502,102	1.27	

[a] Authority, California State engineering department from 1878 to 1884, inclusive.

Estimated monthly discharge of Tuolumne River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1880.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
anuary	1,290	170	409	25,148	0.25	0.29
bruary	5,150	130	625	35,950	.38	.41
arch	1,550	370	832	51,157	.51	.59
pril	19,300	770	7,141	424,918	4.37	4.87
ay	16,300	6,280	10,371	637,687	6.34	7.31
ne	17,050	10,340	14,075	837,521	8.61	9.61
ly	13,220	3,295	7,618	468,412	4.66	5.37
ugust	2,960	300	1,233	75,814	.75	.86
ptember			134	7,973	.08	.09
ctober			56	3,443	.03	.03
ovember			35	2,082	.02	.02
ecember	5,020		1,095	67,328	.67	.77
The year			3,635	2,637,433	2.22	30.22
1881.						
anuary	22,900	2,640	2,884	177,330	1.76	2.03
ebruary	5,020	2,440	6,755	375,153	4.13	4.30
arch	10,340	3,290	2,879	177,022	1.76	2.03
pril	10,200	4,790	6,260	372,495	3.83	4.27
ay	8,630	3,540	7,274	447,261	4.45	5.13
ne	8,970	690	5,225	310,909	3.20	3.57
ly	1,380		1,996	122,729	1.22	1.41
ugust			391	24,041	.24	.28
ptember			125	7,437	.08	.09
ctober			130	7,993	.08	.09
ovember			193	11,484	.12	.13
ecember			620	38,122	.38	.44
The year			2,894	2,071,976	1.77	23.77

Estimated monthly discharge of Tuolumne River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1882.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet*	In.
January			620	38,122	0.38	
February	1,360		573	31,823	.35	
March	11,410	430	2,164	133,059	1.32	
April	5,780	2,270	3,543	210,823	2.17	
May	11,250	4,670	7,461	458,759	4.56	
June	13,670	4,550	8,046	478,770	4.92	
July	5,650	890	2,745	168,783	1.68	
August			574	35,294	.35	
September			255	13,388	.14	
October			873	43,678	.53	
November			570	33,917	.35	
December			327	20,106	.20	
The year			2,310	1,666,522	1.41	
1883.						
January			654	40,211	0.40	
February			490	27,213	.30	
March			1,310	80,548	.80	
April			3,270	194,578	2.00	
May			8,180	502,968	5.00	
June			6,540	389,157	4.00	
July			1,635	100,532	1.00	
August			490	30,129	.30	
September			327	19,457	.20	
October			262	16,110	.16	
November			327	19,457	.20	
December			327	20,106	.20	
The year			1,984	1,440,466	1.21	
1884.						
January			410	25,210	0.25	
February			490	28,185	.30	
March			6,540	402,129	4.00	
April			7,360	437,950	4.50	
May			7,360	452,548	4.50	
June			8,180	486,743	5.00	
July			6,540	402,129	4.00	
August			1,635	100,532	1.00	
September			327	19,457	.20	
October			245	15,064	.15	

Estimated monthly discharge of Tuolumne River, etc.—Continued.

Month.	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1895.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
nuary	16,130	1,398	4,828	296,900	3.22	3.70
bruary	19,650	1,322	3,915	217,430	2.61	2.72
arch	10,785	1,710	3,165	194,610	2.11	2.43
pril	10,012	3,255	5,824	346,570	3.88	4.33
ay	16,000	6,097	11,798	725,400	7.87	9.07
ne	12,530	5,616	9,163	545,110	6.11	6.82
ly	6,692	1,550	3,831	235,540	2.55	2.94
ugust	1,550	285	848	52,125	.57	.65
ptember	5,616	200	615	36,600	.41	.46
ctober	200	120	152	9,346	.10	.12
ovember	500	210	255	14,985	.17	.19
ecember	730	180	283	17,405	.19	.22
The year	19,650	120	3,719	2,692,021	2.45	33.65
1896.						
anuary	13,868	246	3,080	189,370	2.05	2.37
ebruary	1,880	950	1,182	68,007	.79	.86
larch	11,798	1,006	2,725	167,578	1.82	2.10
pril	14,873	1,970	3,577	212,828	2.38	2.66
lay	14,754	2,550	5,180	318,500	3.45	3.98
une	14,754	6,990	11,648	693,104	7.09	7.87
uly	8,735	1,306	4,121	253,408	2.75	3.17
ugust	1,118	300	575	35,392	.38	.44
eptember	2,918	220	574	34,191	.38	.43
ctober	474	180	224	13,797	.15	.17
lovember	7,802	273	1,210	72,012	.81	.90
ecember	3,560	516	1,028	63,247	.69	.79
The year	14,754	180	2,927	2,121,434	1.90	25.74

TWIN CREEKS.

Discharge measurements of East Twin Creek in Canyon, San Bernardino

Date.	Hydrographer.
1898.	
June 11	J. B. Lippincott
	Total
Sept. 9	J. B. Lippincott
Sept. 9	do
	Total
1899.	
Mar. 24	S. G. Bennett
Mar. 24	do
	Total
Aug. 25	S. G. Bennett
Aug. 25	do
	Total
1900.	
July 12	S. G. Bennett
	Total
Oct. 1	W. W. Cockins, jr
	Total
1902.	
Apr. 4	S. G. Bennett
	Total
Sept. 4	W. B. Clapp

[a] Ditch. [b] Tunnel. [c] Creek.

Discharge measurements of West Twin Creek in Canyon, San Bernardino County.

Date.	Hydrographer.	Discharge.
1898.		*Sec.-feet.*
une 11	J. B. Lippincott	[a] 1.06
		[b] .68
		[c] .40
	Total	2.14
ept. 9	J. B. Lippincott	.38
1899.		
Iar. 21	S. G. Bennett	3.00
ug. 25	do	.20
1900.		
uly 12	do	.22
ct. 1	W. W. Cockins, jr	.16
1902.		
pr. 4	S. G. Bennett	3.20
ept. 4	W. B. Clapp	.13

[a] Pipe line to Waterman Ranch. [b] Flume to Settlers. [c] Hot Springs at Old Ranch.

WALKER RIVER.

Discharge measurements of Walker River, East Fork.

Date.	Hydrographer.	Discharge.	Location.
1902.		*Sec.-feet.*	
uly 24	L. H. Taylor	196.5	10 miles below Bridgeport.
ug. 27	D. W. Hays	79.5	Lower end Bridgeport Valley.
ct. 6	do	57.6	Below all diversions in California.
uly 26	F. H. Olmsted	119.8	Robinson Creek below Twin Lakes.
ug. 21	D. W. Hays	75.7	Do.
Do	do	43.2	Buckeye Creek west of Bridgeport.
ct. 6	do	24.0	Robinsons Creek, Twin Lakes.
Do	do	20.0	Buckeye Creek, Buckeye Springs.
ct. 7	do	4.2	Somers, southwest of Bridgeport.
Do	do	7.12	Green Creek above Standard Dam.
ct. 5	do	5.7	Virginia Creek bridge at Huntoon Ranch.

Discharge measurements of Walker River, West Fork.

Date.	Hydrographer.	Discharge.	Location.
1902.		*Sec.-feet.*	
July 22	F. H. Olmsted	417.0	3 miles above Larsens.
Do	do	15.5	Silver Creek.
July 23	do	10.5	Quinton Creek.
Do	do	71.5	Leavitt.
July 24	do	95.0	At Middle Fork.
July 25	L. H. Taylor	330.6	Upper end Antelope Valley.
Aug. 23	D. W. Hays	69.7	Do.
Oct. 4	do	69.8	Do.
Aug. 8	do	221.8	Bridge above tollhouse.

Discharge measurement of Big Walker River, Learitts, Mono County.

Date.	Hydrographer.	Discharge.	Location.
1896.		*Sec.-feet.*	
Oct. 18	J. B. Lippincott	45	

Discharge measurement of Little Walker River, Hardys, Mono County.

Date.	Hydrographer.	Discharge.	Location.
1896.		*Sec.-feet.*	
Oct. 17	J. B. Lippincott	39	
1902.			
July 24.	F. H. Olmsted	101.6	Blackburns Junction.

WARD AND WARREN DITCH.

See San Bernardino Valley.

WARM CREEK.

WARM CREEK, HAWES AND TALMADGE DITCH.

See San Bernardino Valley.

WARM CREEK, M'KENZIE DITCH.

See San Bernardino Valley.

WARM CREEK, MEEKS AND DAILY DITCH.

See San Bernardino Valley.

WARM CREEK, RABEL DITCH (DAM).

See San Bernardino Valley.

WARM CREEK, SHAY OR STOUT DITCH.

See San Bernardino Valley.

WHITE CREEK.

timated monthly discharge of White Creek at base of foothills, Tulare County.[a]

[Drainage area, 90 square miles.]

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1879.	*Second-feet.*	*Acre-feet.*	*Second-feet.*	*Inches.*
nuary	7	430	0.08	0.09
ebruary	12	666	.14	.14
arch	6	369	.07	.08
pril	23	1,368	.25	.28
ay	16	984	.18	.21
ne	5	297	.06	.07
ly	0		0	0
ugust	0		0	0
eptember	0		0	0
ctober	0		0	0
ovember	23	1,368	.25	.28
ecember	45	2,767	.50	.58
The year	11	8,249	.13	1.73

[a] The entire record is estimated from records of neighboring drainage basins. Authority, alifornia State engineering department.

Estimated monthly discharge of White Creek, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth
1880.	*Second-feet.*	*Acre-feet.*	*Second-feet.*	*Inches.*
January	108	6,640	1.20	
February	207	11,906	2.30	
March	234	14,388	2.60	
April	261	15,530	2.90	
May	180	11,067	2.00	
June	45	2,677	.50	
July	5	307	.06	
August	0		0	
September	0		0	
October	0		0	
November	18	1,071	.20	
December	45	2,767	.50	
The year	92	66,353	1.02	
1881.				
January	45	2,767	0.50	
February	90	4,998	1.00	
March	90	5,534	1.00	
April	90	5,355	1.00	
May	90	5,534	1.00	
June	45	2,677	.50	
July	0		0	
August	0		0	
September	0		0	
October	0		0	
November	0		0	
December	11	676	.12	
The year	38	27,541	.42	

Estimated monthly discharge of White Creek, etc.—Continued.

Month.	Mean discharge.	Total discharge.	Run-off.	
			Per square mile.	Depth.
1882.	*Second-feet.*	*Acre-feet.*	*Second-feet.*	*Inches.*
anuary	11	676	0.12	0.14
ebruary	14	777	.15	.16
[arch	45	2,767	.50	.58
pril	45	2,677	.50	.56
[ay	9	553	.10	.12
une	0		0	0
uly	0		0	0
ugust	0		0	0
eptember	0		0	0
ctober	9	553	.10	.12
[ovember	14	833	.15	.17
ecember	5	307	.06	.07
The year	13	9,143	.14	1.92
1883.				
anuary	14	861	0.15	0.17
'ebruary	14	777	.15	.16
[arch	72	4,427	.80	.92
pril	45	2,677	.50	.56
[ay	36	2,213	.40	.46
une	0		0	0
uly	0		0	0
ugust	0		0	0
eptember	0		0	0
)ctober	9	553	.10	.12
[ovember	9	535	.10	.11
)ecember	14	861	.15	.17
The year	18	12,904	.19	2.67

Estimated monthly discharge of White Creek, etc.—Continued.

Month.	Mean discharge	Total discharge.	Run-off	
			Per square mile.	Depth
1884.	*Second-feet.*	*Acre-feet.*	*Second-feet*	*Inch.*
January	45	2,767	0.50	0.5
February	270	15,530	3.00	3.
March	270	16,601	3.00	3.4
April	180	10,710	2.00	2.
May	36	2,213	.40	.
June	45	2,677	.50	.
July	0		0	
August	0		0	
September	0		0	
October	0		0	

WHITEWATER RIVER.

Discharge measurements of Whitewater River and tributaries at various points in San Bernardino and Riverside counties.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Feb. 15, 1898	J. B. Lippincott	7.42	South Fork at tunnel.
Mar. 4, 1899	do	2.52	Do.
Feb. 16, 1898	do	14.24	Main river at foot of Bear Valley trail.
Feb. 17, 1898	do	4.64	North Fork at mouth.
Do	do	.82	Middle Fork at mouth.
Do	do	17.77	Main river 2 miles above mouth.

Discharge measurements of Bear Valley Ditch, Riverside County.

Date.	Hydrographer.	Discharge.	Locality.
		Sec.-feet.	
Feb. 17, 1898	J. B. Lippincott	3.05	¼ mile northeast of ranch house.
Sept. 28, 1899	do	5.20	At headgate.
Sept. 29, 1899	do	2.49	1 mile below headgate.

Discharge measurements of Bear Valley and Palm Spring joint headworks, mouth of Canyon, Riverside County.

Date.	Hydrographer.	Discharge.
		Sec.-feet.
Sept. 7, 1898	J. B. Lippincott	9.35
Aug. 25, 1899	S. G. Bennett	6.34

WHITING DITCH.

See San Bernardino Valley.

WILLOW CREEK.

See Susan River.

YUBA RIVER.

Discharge measurements of Yuba River.

Date.	Hydrographer.	Discharge.	Locality.
1878.		*Sec.-feet.*	
Dec. 9	State engineering department.	510	Marysville.
Dec. 12	....do	510	3 miles below Smartsville.
1879.			
Feb. 14	....do	18,000	Marysville.
Mar. 6	....do	25,750	Do.
Mar. 9	....do	11,500	Do.
Mar. 12	....do	9,500	Do.
Mar. 19	....do	7,000	Do.
Aug. 28	....do	600	Smartsville to Marysville.

Discharge measurements of Yuba River below Parks Bar Bridge, Smartsville, Yuba County, Cal.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Second-feet.*
June 28	H. D. H. Connick	3.15	1,[illegible]
June 29	do	2.95	1,086
July 11	do	2.65	[illegible]
July 12	do	2.65	[illegible]
July 13	do	2.60	[illegible]
July 22	do	2.42	[illegible]
July 23	do	2.50	[illegible]
July 24	do	2.50	[illegible]
Aug. 7	do	2.23	[illegible]
Aug. 8	do	2.30	[illegible]
Aug. 14	do	2.25	[illegible]
Aug. 28	do	2.20	[illegible]
Sept. 14	do	2.60	[illegible]
1902.			
Sept. 1	Chas. A. Miller		[illegible]

Discharge measurements of Yuba River, North Fork, above power company's dam, Yuba County, Cal.

Date.	Hydrographer.	Gage height.	Discharge.
1900.		*Feet.*	*Second-feet.*
July 3	H. D. H. Connick	2.05	[illegible]
July 6	do	1.95	[illegible]
July 17	do	1.70	[illegible]
July 18	do	1.65	[illegible]
July 27	do	1.65	[illegible]
July 29	do	1.60	[illegible]
July 31	do	1.60	[illegible]
Aug. 9	do	1.55	[illegible]
Aug. 10	do	1.57	[illegible]
Aug. 29	do	1.48	[illegible]
Aug. 30	do	1.48	[illegible]

charge measurements of Yuba River, Middle Fork, at Freemans Bridge, Yuba County, Cal.

Date.	Hydrographer.	Gage height.	Discharge.
900.		*Feet.*	*Sec.-feet*
ly 1	H. D. H. Connick	2.40	191
ly 3	do	2.35	180
ly 4	do	2.30	185
ly 7	do	2.57	162
ly 29	do	2.30	109
g. 11	do	2.17	79
g. 12	do	2.15	78
g. 29	do	2.20	69
g. 30	do	2.20	68
ot. 18	do	2.15	64

Discharge measurements of Yuba River, Yuba County, Cal.

Date.	Hydrographer.	Discharge.	Locality.
1902.		*Sec.-feet.*	
ıg. 29	S. G. Bennett	58	South Fork, at Eldorado bridge.
ıg. 30	Chas. A. Miller	55	South Fork, at Bridgeport bridge.
pt. 1	do	32	Excelsior Mining and Irrigation canal, at Pleasant Valley.
	Total	87	
ıg. 29	S. G. Bennett	58	South Fork, 75 feet above Edwards bridge.
Do	do	9.3	South Fork, North Columbia, Eureka Lake Company's canal.
Do	do	7.0	South Fork, North Bloomfield ditch.
ıg. 30	do	52	Middle Fork, ¼ mile below Delihi mine.
pt. 1	do	64	Middle Fork, 300 feet below Freemans bridge.
Do	do	221	North Fork, Bay Counties Electric Co.'s flume, below headgate.

MAXIMUM FLOOD MEASUREMENTS.

The following flood measurements are given as having peculiar interest to the engineer in connection with the designing of bridges and of spillways for reservoirs. It is not intended that these should be considered as the maximum floods that will ever occur on the drainage basins. They are rather given as a record of the largest observed volumes known to the author. It is, of course, exceedingly difficult to measure accurately a river in great flood, and it seldom falls to the fortune of a hydrographer to be present at the maximum flood wave, but it is believed that these data may be valuable for the purposes mentioned:

Gila River at Florence, Ariz., February, 1891; 17,750 square miles drainage area; discharge, 102,500 second-feet, or 7.5 second-feet per square mile.

Salt River, Arizona, February, 1891; area of drainage, 12,000 square miles; flood discharge, 300,000 second-feet, or 24.6 second-feet per square mile.

Gila River at Gila bend, February, 1891, probable flood discharge, 250,000 second-feet.

Mormon Canyon, Los Angeles County, 15¼ square miles drainage; elevations from 1,000 to 3,800; flood discharge by Schuyler from 700 to 800 second-feet, or 48.5 second-feet per square mile.

Sweetwater River, 186 square miles drainage area; January, 1895, 18,150 second-feet, or 97.5 second-feet per square mile.

Tuolumne River at La Grange dam, drainage area, 1,501 square miles; elevations to 14,000 feet; flood discharge, 46,000 second-feet, or 30.6 second-feet per square mile.

Yuba River, South Fork, at Bowman dam, elevation, 5,500 feet; drainage area, 19 square miles; discharge, 5,000 to 7,000 second-feet from melting snow, or 263 second-feet per square mile.

Cherry Creek, Colorado, area, 175 square miles; flood discharge, 10,000 second-feet, or 57 second-feet per square mile.

Maximum floods measured by the United States Geological Survey, 1896–1901.

Date	Stream.	Locality.	Area of watershed	Maximum measurements.	Discharge per square mile
			Sq. miles.	*Sec.-feet.*	*Sec.-feet*
	Arroyo Seco (Salinas).	Above diversion	218	24,050	110.23
1885	Kern	Near Bakersfield	2,345	9,380	4.00
1901	King	Red Mountain	1,742	43,930	25.21
1901	Mokelumne	Electra	640	13,213	20.64
1896	Sacramento	Jellys Ferry	9,134	130,050	14.23
1900	San Antonio	Near Jolon (above Pinkerton dam site).	322	15,315	47.56
1901	San Gabriel	Azusa	222	6,250	28.15
1901	San Joaquin	Herndon	1,637	21,372	13.05
1900	San Lorenzo		235	10,269	42.00
1900	Santa Ana	Warm Spring	188	1,564	8.32
1899	Stanislaus	Oakdale	1,051	13,940	13.26
1900	Stony Creek	Julian's ranch	760	[a] 18,000	23.76+
1899	Tuolumne	Lagrange	1,501	21,800	14.52

[a] Gage height, 14. February, 1902, gage height reached 15.7.

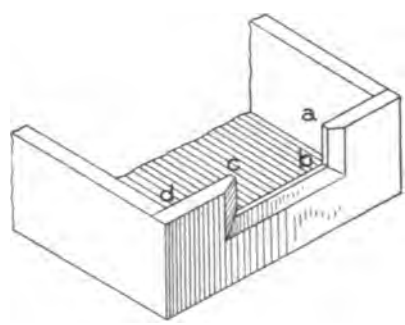

FIG. 4. Figure showing construction of weir.

It has been found that the usual method of measuring the head on weirs, as practiced by water companies and water users, is to use an ordinary foot rule divided into inches and sixteenths. As no general weir table is available for heads so measured, the following has been prepared.

WEIR.

The following conditions should be observed in construction of weir: depth of box or canal, and distance c d of opening from side of canal

Discharges in second-feet, rectangular weir

[Formula of ...]

	Head.		Length of weir.												
	Inches.	Feet.	4 in.	6 in.	9 in.	12 in.	15 in.	18 in.	24 in.	2 ft. 6 in.	3 ft.	3 ft. 6 in.	4 ft.	4 ft. 6 in.	
1	$\frac{1}{16}$	0.005													
2	$\frac{1}{8}$	.010	0.0011	0.0017	0.0026	0.00353									
3	$\frac{3}{16}$	.015	.0021	.0032	.0048	.00648									
4	$\frac{1}{4}$	.021	.0033	.0050	.0075	.00997	0.0125	0.0150	0.0200	0.0250	0.0300	0.0350	0.0401		
5	$\frac{5}{16}$	.026	.0046	.0069	.0104	.0139	.0174	.0209	.0279	.0349	.0419	.0489	.0559		
6	$\frac{3}{8}$	.031	.0060	.0091	.0137	.0183	.0229	.0275	.0367	.0459	.0551	.0643	.0735		
7	$\frac{7}{16}$	.036	.0075	.0114	.0172	.0230	.0288	.0346	.0462	.0578	.0694	.0810	.0926		
8	$\frac{1}{2}$	.042	.0092	.0139	.0210	.0281	.0352	.0422	.0564	.0706	.0847	.0989	.113		
9	$\frac{9}{16}$	.047	.0110	.0166	.0250	.0335	.0419	.0504	.0673	.0842	.101	.118	.135		
10	$\frac{5}{8}$	.052	.0128	.0194	.0293	.0392	.0491	.0590	.0788	.0986	.118	.138	.158		
11	$\frac{11}{16}$	.057	.0147	.0223	.0337	.0451	.0566	.0680	.0908	.114	.136	.159	.182		
12	$\frac{3}{4}$	.062	.0167	.0254	.0384	.0514	.0644	.0774	.103	.129	.155	.181	.207		
13	$\frac{13}{16}$	.068	.0187	.0285	.0432	.0579	.0725	.0872	.117	.146	.175	.205	.234		
14	$\frac{7}{8}$	.073	.0209	.0318	.0482	.0646	.0810	.0974	.130	.163	.196	.229	.261		
15	$\frac{15}{16}$	.078	.0231	.0352	.0534	.0716	.0897	.108	.144	.181	.217	.253	.290		
16	1	.083	.0254	.0387	.0587	.0788	.0988	.119	.159	.199	.239	.279	.319		
17	$1\frac{1}{16}$	.088	.0277	.0423	.0642	.0862	.108	.130	.174	.218	.262	.305	.349		
18	$1\frac{1}{8}$	.094	.0301	.0460	.0699	.0938	.118	.142	.189	.237	.285	.333	.380		
19	$1\frac{3}{16}$	.099	.0325	.0498	.0757	.102	.128	.153	.205	.257	.309	.361	.413		
20	$1\frac{1}{4}$	.104	.0349	.0536	.0816	.110	.138	.166	.222	.278	.334	.389	.445		
21	$1\frac{5}{16}$	.109	.0375	.0576	.0877	.118	.148	.178	.238	.298	.359	.419	.479		
22	$1\frac{3}{8}$	.115	.0401	.0616	.0939	.126	.159	.191	.255	.320	.385	.449	.514		
23	$1\frac{7}{16}$	.120	.0427	.0657	.100	.135	.169	.204	.273	.342	.411	.480	.549		
24	$1\frac{1}{2}$	.125	.0454	.0699	.107	.144	.180	.217	.291	.364	.438	.511	.585		
25	$1\frac{9}{16}$	.130	.0481	.0742	.113	.152	.192	.231	.309	.387	.465	.544	.622		
26	$1\frac{5}{8}$	.135	.0508	.0784	.120	.161	.203	.244	.327	.410	.493	.576	.659		
27	$1\frac{11}{16}$	.140	.0536	.0829	.127	.171	.215	.259	.346	.434	.522	.610	.698		
28	$1\frac{3}{4}$	.146	.0564	.0873	.134	.180	.226	.273	.365	.458	.551	644	.736		
29	$1\frac{13}{16}$	.151	.0593	.0919	.141	.190	.238	.287	.385	.483	.581	.678	.776		
30	$1\frac{7}{8}$	.156	.0622	.0965	.148	.199	.251	.302	.405	.508	.611	.714	.816		
31	$1\frac{15}{16}$	.161	.0651	.101	.155	.209	.263	.317	.425	.533	.641	.749	.857		
32	2	.167	.0680	.106	.162	.219	.276	.332	.446	.559	.672	.786	.899		
33	$2\frac{1}{16}$	.172	.0710	.111	.170	.229	.288	.348	.466	.585	.704	.822	.941		
34	$2\frac{1}{8}$	.177	.0740	.115	.177	.239	.301	.364	.488	.612	.736	.860	.984		
35	$2\frac{3}{16}$	.182	.0769	.120	.185	.250	.315	.379	.509	.638	.768	.898	1.027		
36	$2\frac{1}{4}$	.187	.0799	.125	.193	.260	.328	.395	.531	.666	.801	.936	1.071		
37	$2\frac{5}{16}$	.193	.0830	.130	.201	.271	.341	.412	.553	.694	834	.975	1.116		
38	$2\frac{3}{8}$	.198	.0862	.135	.208	.282	.355	.428	.575	.722	.868	1.015	1.161		
39	$2\frac{7}{16}$	.203	.0893	.140	.216	.293	.369	.445	.597	.750	.902	1.055	1.207		
40	$2\frac{1}{2}$	.208	.0924	.145	.224	.303	.383	.462	.620	.778	.937	1.095	1.253		
41	$2\frac{9}{16}$	.213	.....	.150	.233	.315	.397	.479	.643	.808	.972	1.136	1.300		
42	$2\frac{5}{8}$	.219	.....	.155	.241	.326	.411	.496	.667	.837	1.007	1.178	1.348		
43	$2\frac{11}{16}$	.224	.....	.161	.249	.337	.425	.514	.690	.867	1.043	1.219	1.396		
44	$2\frac{3}{4}$	.229	.....	.166	.257	.349	.440	.531	.714	.897	1.079	1.262	1.444		

ABLES.

ie depth *a b* of weir (fig. 4, see p. 411) must not be over one-third ust not be less than depth *a b*.

th end contractions; original computation.

.2 H) $H^{\frac{3}{2}}$.]

Length of weir—Continued.											Addition for increase of length.		
5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.	1 in.	1 ft.	
													1
											0.00029	0.00354	2
											.00054	.00650	3
0.0500	0.0600	0.0700	0.0800	0.0900	0.100	0.120	0.140	0.160	0.180	0.200	.00083	.01001	4
.0838	.0838	.0978	.119	.126	.140	.168	.196	.224	.252	.280	.00117	.0140	5
.0918	.110	.129	.147	.166	.184	.221	.258	.294	.331	.368	.00153	.0184	6
.116	.139	.162	.185	.209	.232	.278	.324	.371	.417	.463	.00193	.0232	7
.141	.170	.198	.226	.255	.283	.340	.396	.453	.510	.566	.00236	.0283	8
.169	.203	.236	.270	.304	.338	.405	.473	.541	.608	.676	.00282	.0338	9
.198	.237	.277	.316	.356	.395	.475	.554	.633	.712	.791	.00330	.0396	10
.228	.273	.319	.365	.410	.456	.547	.639	.730	.821	.913	.00380	.0457	11
.260	.312	.364	.416	.468	.520	.624	.728	.832	.936	1.040	.00433	.0520	12
.293	.351	.410	.469	.527	.586	.703	.821	.938	1.055	1 173	.00489	.0587	13
.327	.392	.458	.524	.589	.655	.786	.917	1.048	1.179	1.310	.00546	.0656	14
.362	.435	.509	.582	.654	.726	.872	1.017	1.162	1.308	1.453	.00606	.0727	15
.399	.479	.559	.640	.720	.800	.960	1.120	1.280	1.441	1.601	.00667	.0801	16
.437	.525	.613	.700	.788	.876	1.051	1.227	1.402	1.578	1.753	.00731	.0877	17
.476	.572	.667	.763	.859	.954	1.145	1.337	1.528	1.719	1.910	.00796	.0956	18
.516	.620	.724	.827	.931	1.035	1.242	1.449	1.657	1.864	2.071	.00864	.104	19
.557	.669	.781	.893	1.005	1.117	1.341	1.565	1.789	2.013	2.237	.00933	.112	20
.600	.720	.841	.961	1.081	1.202	1.443	1.684	1.925	2.166	2.407	.01005	.120	21
.643	.772	.901	1.030	1.160	1.289	1.547	1.805	2.064	2.322	2.580	.0108	.129	22
.687	.825	.963	1.101	1.239	1.377	1.654	1.930	2.206	2.482	2.758	.0115	.138	23
.732	.879	1.026	1.174	1.321	1.468	1.762	2.057	2.351	2.645	2.940	.0123	.147	24
.778	.935	1.091	1.248	1.404	1.561	1.874	2.186	2.499	2.812	3.125	.0130	.156	25
.825	.991	1.157	1.323	1.489	1.655	1.987	2.319	2.650	2.982	3.314	0138	.166	26
.873	1.049	1.224	1.400	1.576	1.751	2.102	2.454	2.805	3.156	3.507	.0146	176	27
.922	1.107	1.293	1.478	1.664	1.849	2.220	2.591	2.962	3.333	3.704	.0155	185	28
.971	1.167	1.362	1.558	1.753	1.949	2.340	2.731	3.122	3.513	3.904	.0163	.195	29
1.022	1.228	1.433	1.639	1.845	2.050	2.462	2.873	3.284	3.696	4.107	0171	.206	30
1.073	1.289	1.505	1.721	1.937	2.153	2.586	3.018	3.450	3.882	4.314	.0180	.216	31
1.125	1.352	1.579	1.805	2.032	2.258	2.711	3.165	3.618	4.071	4.524	.0189	.227	32
1.178	1.416	1.653	1.890	2.127	2.365	2.839	3.314	3.788	4.263	4.737	0198	.237	33
1.232	1.480	1.728	1.976	2.225	2.473	2.969	3.465	3.962	4.458	4.954	.0207	.248	34
1.286	1.546	1.805	2.064	2.323	2.582	3.101	3.619	4.138	4.656	5.174	.0216	.259	35
1.342	1.612	1.882	2.153	2.423	2.693	3.234	3.775	4.316	4.856	5.397	.0225	270	36
1.398	1.680	1.961	2.243	2.525	2.806	3.370	3.933	4.497	5.060	5.623	.0235	282	37
1.455	1.748	2.041	2.334	2.627	2.921	3.507	4.093	4.680	5.266	5.853	.0244	.293	38
1.512	1.817	2.122	2.427	2.731	3.036	3.648	4.256	4.865	5.475	6.085	0254	.305	39
1.570	1.887	2.203	2.520	2.837	3.153	3.787	4.420	5.053	5.686	6.320	.0264	.317	40
1.629	1.958	2.286	2.615	2.943	3.272	3.929	4.586	5.244	5.901	6.558	.0274	.329	41
1.689	2.029	2.370	2.711	3.051	3.392	4.074	4.755	5.436	6.118	6.799	.0284	.341	42
1.749	2.102	2.455	2.808	3.161	3.514	4.219	4.925	5.631	6.337	7.043	0294	.353	43
1.810	2.175	2.540	2.906	3.271	3.636	4.367	5.098	5.828	6.559	7.290	.0304	.365	44

Discharges in second-feet, rectang

	Head.		Length of weir.											
	Inches.	Feet.	4 in.	6 in.	9 in.	12 in.	15 in.	18 in.	24 in.	2 ft. 6 in.	3 ft.	3 ft. 6 in.	4 ft.	4 ft. 6 in.
45	2 1/8	0.234		0.171	0.266	0.360	0.455	0.549	0.738	0.927	1.116	1.305	1.494	
46	2¼	.240		.177	.274	.372	.469	.567	.762	.958	1.153	1.348	1.543	
47	2 3/8	.245		.182	.283	.384	.484	.585	.787	.989	1.190	1.392	1.594	
48	3	.250		.187	.291	.395	.499	.604	.812	1.020	1.228	1.436	1.644	
49	3 1/8	.255		.193	.300	.407	.515	.622	.837	1.051	1.266	1.481	1.696	
50	3¼	.260		.198	.308	.420	.530	.641	.862	1.083	1.305	1.526	1.747	
51	3 3/8	.266		.204	.318	.432	.546	.660	.888	1.116	1.343	1.571	1.799	
52	3½	.271		.209	.327	.444	.561	.679	.913	1.148	1.383	1.617	1.852	
53	3 5/8	.276		.215	.336	.456	.577	.698	.939	1.181	1.422	1.664	1.906	
54	3¾	.281		.220	.345	.469	.593	.717	.966	1.214	1.462	1.711	1.959	
55	3 7/8	.286		.226	.354	.481	.609	.737	.992	1.247	1.502	1.758	2.013	
56	3¾	.292		.232	.363	.494	.625	.756	1.018	1.281	1.543	1.805	2.068	
57	3 9/8	.297			.372	.507	.641	.776	1.045	1.315	1.584	1.853	2.122	
58	3½	.302			.381	520	.658	.796	1.072	1.349	1.625	1.902	2.178	
59	3 11/16	.307			.391	.532	.674	.816	1.100	1.383	1.667	1.950	2.233	
60	3¾	.312			.400	.545	.691	.836	1.127	1.418	1.709	2.000	2.291	
61	3 13/16	.318			.409	.558	.708	.857	1.155	1.453	1.751	2.049	2.347	
62	3¾	.323			.419	.572	.724	.877	1.183	1.488	1.794	2.099	2.405	
63	3 15/16	.328			.428	.585	.741	.898	1.211	1.524	1.837	2.150	2.463	
64	4	.333			.438	.598	.758	.919	1.239	1.559	1.880	2.200	2.521	
65	4 1/16	.338			.448	.612	.776	.940	1.267	1.595	1.923	2.251	2.579	
66	4¼	.344			.457	.625	.793	.961	1.296	1.632	1.967	2.303	2.638	
67	4 1/8	.349			.467	.638	.810	.982	1.325	1.668	2.011	2.355	2.698	
68	4¼	.354			.477	.652	.828	1.003	1.354	1.705	2.056	2.407	2.758	
69	4 5/16	.359			.486	.666	.845	1.025	1.383	1.742	2.101	2.459	2.818	
70	4⅜	.365			.496	.680	.863	1.046	1.413	1.779	2.146	2.512	2.879	
71	4 7/16	.370			.506	.693	.881	1.068	1.442	1.817	2.191	2.565	2.940	
72	4½	.375			.516	.707	.899	1.090	1.472	1.854	2.237	2.619	3.001	
73	4 9/16	.380				.721	.917	1.112	1.502	1.892	2.283	2.673	3.065	
74	4⅝	.385				.735	.935	1.134	1.532	1.930	2.329	2.727	3.126	
75	4 11/16	.390				.749	.953	1.156	1.562	1.969	2.375	2.782	3.188	
76	4¾	.396				.764	.971	1.178	1.593	2.008	2.422	2.837	3.251	
77	4 13/16	.401				.778	.989	1.201	1.624	2.047	2.469	2.892	3.315	
78	4⅞	.406				.793	1.009	1.224	1.655	2.086	2.517	2.949	3.381	
79	4 15/16	.411				.807	1.028	1.246	1.686	2.125	2.565	3.004	3.444	
80	5	.417				.821	1.045	1.269	1.717	2.164	2.612	3.060	3.508	
81	5 1/16	.422				.836	1.064	1.292	1.748	2.205	2.661	3.117	3.573	
82	5⅛	.427				.850	1.082	1.315	1.779	2.244	2.709	3.174	3.638	
83	5 3/16	.432				.864	1.101	1.337	1.810	2.284	2.757	3.230	3.703	
84	5¼	.437				.879	1.120	1.361	1.843	2.324	2.806	3.288	3.770	
85	5 5/16	.443				.893	1.138	1.385	1.874	2.364	2.855	3.345	3.836	
86	5⅜	.448				.908	1.158	1.407	1.906	2.405	2.904	3.404	3.903	
87	5 7/16	.453				.923	1.177	1.431	1.939	2.447	2.954	3.462	3.970	
88	5½	.458				.938	1.196	1.455	1.971	2.488	3.005	3.521	4.038	
89	5 9/16	.463				.953	1.216	1.479	2.004	2.530	3.055	3.581	4.106	
90	5⅝	.469				.968	1.235	1.502	2.037	2.571	3.105	3.640	4.174	
91	5 11/16	.474				.983	1.255	1.526	2.070	2.613	3.156	3.700	4.243	
92	5¾	.479				.998	1.274	1.550	2.103	2.655	3.207	3.760	4.312	
93	5 13/16	.484				1.014	1.295	1.575	2.137	2.698	3.259	3.821	4.382	
94	5⅞	.490				1.029	1.314	1.599	2.170	2.740	3.310	3.881	4.451	

s with end contractions—Continued.

	Length of weir - Continued.										Addition for increase of length.		
	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.	1 in.	1 ft.	
.871	2.249	2.627	3.005	3.383	3.761	4.516	5.272	6.028	6.783	7.539	0.0315	0.378	45
.934	2.324	2.715	3.105	3.496	3.886	4.667	5.448	6.229	7.010	7.792	.0325	.391	46
.997	2.400	2.804	3.207	3.610	4.013	4.820	5.627	6.433	7.240	8.047	.0336	.403	47
.060	2.477	2.893	3.309	3.725	4.142	4.974	5.807	6.639	7.472	8.304	.0347	.416	48
.125	2.554	2.983	3.413	3.842	4.271	5.130	5.989	6.847	7.706	8.565	.0358	.429	49
.190	2.632	3.075	3.517	3.960	4.402	5.287	6.172	7.058	7.943	8.828	.0369	.443	50
.255	2.711	3.167	3.623	4.079	4.535	5.446	6.358	7.270	8.182	9.093	.0380	.456	51
.321	2.791	3.260	3.729	4.199	4.668	5.607	6.546	7.484	8.423	9.362	.0391	.469	52
.388	2.871	3.354	3.837	4.320	4.803	5.769	6.735	7.701	8.666	9.632	.0402	.483	53
.455	2.952	3.449	3.946	4.442	4.939	5.932	6.926	7.919	8.913	9.906	.0414	.497	54
.524	3.034	3.545	4.055	4.566	5.076	6.097	7.118	8.140	9.161	10.182	.0425	.511	55
.592	3.117	3.641	4.166	4.690	5.215	6.264	7.313	8.362	9.411	10.460	.0437	.525	56
.661	3.200	3.739	4.277	4.816	5.355	6.432	7.509	8.586	9.664	10.741	.0449	.539	57
.731	3.284	3.837	4.390	4.943	5.495	6.601	7.707	8.813	9.918	11.024	.0461	.553	58
.801	3.369	3.936	4.503	5.070	5.638	6.772	7.907	9.041	10.176	11.310	.0473	.567	59
.872	3.454	4.036	4.617	5.199	5.781	6.944	8.108	9.271	10.435	11.598	.0485	.582	60
.944	3.540	4.136	4.733	5.329	5.925	7.118	8.311	9.503	10.696	11.889	.0497	.596	61
3.016	3.627	4.238	4.849	5.460	6.071	7.293	8.515	9.737	10.960	12.182	.0509	.611	62
3.088	3.714	4.340	4.966	5.592	6.218	7.470	8.722	9.973	11.225	12.477	.0522	.626	63
3.162	3.802	4.443	5.084	5.725	6.366	7.648	8.929	10.211	11.493	12.774	.0534	.641	64
3.235	3.891	4.547	5.203	5.859	6.515	7.827	9.139	10.451	11.763	13.074	.0547	.656	65
3.310	3.981	4.652	5.323	5.994	6.665	8.007	9.350	10.692	12.034	13.377	.0559	.671	66
3.384	4.071	4.757	5.443	6.130	6.816	8.189	9.562	10.935	12.308	13.681	.0572	.686	67
3.460	4.161	4.863	5.565	6.267	6.969	8.373	9.776	11.180	12.584	13.988	.0585	.702	68
3.535	4.253	4.970	5.688	6.405	7.122	8.557	9.992	11.427	12.862	14.296	.0598	.717	69
3.612	4.345	5.078	5.811	6.544	7.277	8.743	10.209	11.676	13.142	14.609	.0611	.733	70
3.689	4.438	5.186	5.935	6.684	7.433	8.930	10.428	11.926	13.423	14.921	.0624	.749	71
3.766	4.531	5.296	6.060	6.825	7.590	9.119	10.648	12.178	13.707	15.237	.0637	.765	72
3.844	4.625	5.405	6.186	6.967	7.748	9.309	10.870	12.432	13.993	15.553	.0650	.781	73
3.922	4.719	5.516	6.313	7.110	7.906	9.500	11.093	12.687	14.281	15.874	.0664	.797	74
4.001	4.814	5.627	6.440	7.253	8.066	9.692	11.318	12.944	14.570	16.195	.0677	.813	75
4.081	4.910	5.739	6.569	7.398	8.227	9.885	11.545	13.203	14.862	16.520	.0691	.829	76
4.161	5.007	5.852	6.698	7.544	8.390	10.081	11.772	13.464	15.155	16.847	.0705	.846	77
4.242	5.104	5.967	6.829	7.691	8.553	10.278	12.002	13.727	15.451	17.176	.0719	.862	78
4.323	5.201	6.080	6.959	7.838	8.717	10.475	12.233	13.990	15.748	17.506	.0732	.879	79
4.404	5.299	6.195	7.090	7.986	8.882	10.673	12.464	14.255	16.047	17.838	.0747	.896	80
4.486	5.398	6.311	7.223	8.136	9.048	10.873	12.69	14.523	16.348	18.173	.0760	.912	81
4.568	5.497	6.427	7.356	8.285	9.215	11.074	12.933	14.791	16.650	18.509	.0775	.929	82
4.650	5.596	6.543	7.489	8.436	9.382	11.275	13.168	15.061	16.954	18.847	.0789	.946	83
4.733	5.697	6.661	7.624	8.588	9.551	11.479	13.406	15.333	17.260	19.187	.0803	.964	84
4.816	5.797	6.778	7.759	8.740	9.721	11.682	13.644	15.605	17.567	19.528	.0817	.981	85
4.901	5.899	6.897	7.895	8.894	9.892	11.888	13.885	15.881	17.877	19.871	.0832	.998	86
4.986	6.002	7.017	8.033	9.04	10.064	12.096	14.127	16.159	18.190	20.221	.0846	1.016	87
5.071	6.105	7.138	8.171	9.204	10.238	12.304	14.371	16.438	18.504	20.571	.0861	1.033	88
5.157	6.208	7.259	8.310	9.361	10.412	12.514	14.616	16.718	18.820	20.922	.0876	1.051	89
5.243	6.312	7.380	8.449	9.518	10.586	12.724	14.861	16.999	19.136	21.273	.0891	1.069	90
5.329	6.416	7.503	8.589	9.676	10.762	12.936	15.109	17.282	19.455	21.628	.0906	1.087	91
5.416	6.521	7.626	8.730	9.835	10.939	13.149	15.358	17.567	19.776	21.985	.0921	1.105	92
5.504	6.627	7.750	8.872	9.995	11.117	13.363	15.608	17.853	20.098	22.343	.0935	1.123	93
5.592	6.733	7.873	9.014	10.155	11.295	13.577	15.858	18.140	20.421	22.702	.0951	1.141	94

Discharges in second-feet, rectangular

	Head.		Length of weir.											
	Inches.	Feet.	4 in.	6 in.	9 in.	12 in.	15 in.	18 in.	24 in.	2 ft. 6 in.	3 ft.	3 ft. 6 in.	4 ft.	
95	5 1/8	0.495				1.044	1.334	1.624	2.205	2.783	3.362	3.942	4.52	
96	6	.500				1.080	1.364	1.649	2.237	2.826	3.415	4.008	4.59	
97	6 1/8	.505					1.374	1.673	2.271	2.869	3.467	4.065	4.66	
98	6 1/4	.510					1.394	1.697	2.304	2.912	3.519	4.126	4.73	
99	6 3/8	.515					1.414	1.722	2.339	2.955	3.572	4.188	4.80	
100	6 1/2	.521					1.434	1.747	2.372	2.999	3.624	4.250	4.87	
101	6 5/8	.526					1.455	1.772	2.407	3.043	3.678	4.313	4.94	
102	6 3/4	.531					1.475	1.798	2.442	3.087	3.732	4.377	5.02	
103	6 7/8	.536					1.496	1.822	2.476	3.131	3.785	4.439	5.09	
104	6 1/4	.542					1.516	1.848	2.511	3.175	3.839	4.503	5.16	
105	6 5/8	.547					1.537	1.873	2.547	3.220	3.893	4.567	5.24	
106	6 3/4	.552					1.557	1.898	2.581	3.264	3.947	4.631	5.31	
107	6 1/2	.557					1.577	1.924	2.616	3.309	4.002	4.695	5.38	
108	6 3/4	.562					1.598	1.949	2.652	3.354	4.057	4.758	5.46	
109	6 3/8	.568					1.619	1.975	2.687	3.400	4.112	4.824	5.53	
110	6 1/2	.573					1.640	2.001	2.723	3.445	4.167	4.888	5.61	
111	6 5/8	.578					1.661	2.027	2.759	3.491	4.223	4.955	5.68	
112	7	.583					1.682	2.053	2.795	3.536	4.278	5.021	5.76	
113	7 1/8	.588					1.703	2.079	2.830	3.582	4.334	5.08	5.83	
114	7 1/4	.594					1.725	2.106	2.867	3.628	4.391	5.15	5.91	
115	7 3/8	.599					1.746	2.132	2.904	3.675	4.447	5.219	5.99	
116	7 1/2	.604					1.767	2.158	2.940	3.722	4.504	5.288	6.06	
117	7 5/8	.609					1.788	2.184	2.976	3.768	4.560	5.352	6.14	
118	7 3/4	.615					1.809	2.210	3.012	3.815	4.617	5.419	6.22	
119	7 7/8	.620					1.830	2.236	3.049	3.861	4.674	5.486	6.29	
120	7 1/4	.625					1.851	2.263	3.085	3.908	4.731	5.554	6.37	
121	7 1/8	.630						2.290	3.123	3.956	4.789	5.622	6.45	
122	7 3/8	.635						2.316	3.160	4.003	4.846	5.690	6.53	
123	7 1/8	.641						2.343	3.196	4.050	4.904	5.756	6.61	
124	7 1/4	.646						2.370	3.234	4.098	4.963	5.827	6.69	
125	7 3/8	.651						2.397	3.271	4.146	5.021	5.895	6.77	
126	7 1/2	.656						2.423	3.308	4.193	5.079	5.964	6.85	
127	7 5/8	.661						2.451	3.346	4.242	5.138	6.034	6.93	
128	8	.667						2.477	3.384	4.290	5.196	6.103	7.01	
129	8 1/8	.672						2.505	3.422	4.339	5.256	6.173	7.09	
130	8 1/4	.677						2.532	3.459	4.387	5.315	6.242	7.17	
131	8 3/8	.682						2.559	3.498	4.436	5.374	6.313	7.25	
132	8 1/2	.688						2.586	3.535	4.484	5.433	6.383	7.33	
133	8 5/8	.693						2.614	3.574	4.534	5.494	6.454	7.41	
134	8 3/4	.698						2.642	3.613	4.583	5.554	6.525	7.49	
135	8 7/8	.703						2.669	3.650	4.632	5.614	6.596	7.57	
136	8 1/4	.708						2.697	3.689	4.682	5.674	6.667	7.66	
137	8 1/8	.714						2.725	3.728	4.732	5.735	6.739	7.74	
138	8 3/4	.719						2.752	3.766	4.781	5.795	6.810	7.82	
139	8 1/8	.724						2.780	3.805	4.831	5.856	6.882	7.90	
140	8 1/4	.729						2.808	3.844	4.881	5.918	6.955	7.98	
141	8 3/8	.734						2.836	3.884	4.932	5.979	7.027	8.07	
142	8 1/2	.740						2.863	3.922	4.981	6.040	7.099	8.15	
143	8 5/8	.745						2.891	3.961	5.032	6.102	7.172	8.23	
144	9	.750						2.919	4.001	5.082	6.164	7.245	8.32	

irs with end contractions—Continued.

Length of weir—Continued.											Addition for increase of length.		
5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.	1 in.	1 ft.	
5.680	6.839	7.998	9.157	10.316	11.475	13.793	16.111	18.429	20.747	23.065	0.0986	1.159	95
5.769	6.947	8.124	9.301	10.478	11.656	14.010	16.365	18.720	21.074	23.429	.0981	1.177	96
5.858	7.054	8.250	9.446	10.641	11.837	14.229	16.620	19.012	21.404	23.795	.0997	1.196	97
5.948	7.162	8.376	9.591	10.805	12.020	14.448	16.877	19.306	21.735	24.164	.101	1.214	98
6.038	7.271	8.504	9.737	10.970	12.203	14.669	17.135	19.601	22.067	24.533	.103	1.233	99
6.128	7.380	8.631	9.883	11.135	12.386	14.890	17.393	19.897	22.400	24.903	.104	1.252	100
6.219	7.490	8.760	10.031	11.301	12.572	15.113	17.654	20.195	22.736	25.277	.106	1.271	101
6.311	7.600	8.889	10.179	11.468	12.758	15.336	17.915	20.494	23.073	25.652	.107	1.289	102
6.402	7.710	9.018	10.327	11.635	12.944	15.560	18.177	20.794	23.411	26.028	.109	1.308	103
6.494	7.822	9.149	10.477	11.804	13.132	15.787	18.442	21.097	23.752	26.407	.111	1.328	104
6.587	7.934	9.280	10.627	11.974	13.320	16.014	18.707	21.401	24.094	26.787	.112	1.347	105
6.679	8.045	9.411	10.777	12.143	13.509	16.241	18.973	21.705	24.437	27.169	.114	1.366	106
6.773	8.158	9.543	10.929	12.314	13.700	16.470	19.241	22.012	24.783	27.554	.115	1.385	107
6.866	8.271	9.676	11.081	12.485	13.890	16.700	19.509	22.319	25.129	27.938	.117	1.405	108
6.961	8.385	9.809	11.234	12.658	14.083	16.931	19.780	22.629	25.478	28.327	.119	1.424	109
7.055	8.500	9.944	11.388	12.832	14.276	17.164	20.052	22.941	25.829	28.717	.120	1.444	110
7.150	8.614	10.078	11.542	13.005	14.469	17.397	20.324	23.252	26.180	29.107	.122	1.464	111
7.245	8.729	10.213	11.696	13.180	14.663	17.631	20.598	23.565	26.532	29.499	.124	1.484	112
7.341	8.845	10.348	11.852	13.355	14.859	17.866	20.873	23.880	26.887	29.894	.125	1.504	113
7.438	8.962	10.485	12.009	13.532	15.056	18.103	21.150	24.197	27.244	30.291	.127	1.524	114
7.534	9.078	10.622	12.165	13.709	15.252	18.340	21.427	24.514	27.601	30.688	.129	1.544	115
7.631	9.195	10.759	12.323	13.886	15.450	18.578	21.705	24.833	27.961	31.088	.130	1.564	116
7.728	9.313	10.897	12.481	14.065	15.649	18.817	21.985	25.154	28.322	31.490	.132	1.584	117
7.826	9.430	11.034	12.639	14.243	15.848	19.056	22.265	25.474	28.683	31.892	.134	1.604	118
7.923	9.548	11.173	12.798	14.422	16.047	19.297	22.546	25.796	29.046	32.295	.135	1.625	119
8.022	9.667	11.312	12.958	14.603	16.249	19.539	22.830	26.121	29.412	32.703	.137	1.645	120
8.121	9.787	11.453	13.119	14.785	16.451	19.783	23.115	26.447	29.779	33.111	.139	1.666	121
8.220	9.907	11.593	13.280	14.967	16.653	20.027	23.400	26.774	30.147	33.520	.141	1.687	122
8.319	10.027	11.734	13.442	15.149	16.857	20.272	23.687	27.102	30.517	33.932	.142	1.708	123
8.419	10.148	11.876	13.604	15.332	17.061	20.517	23.974	27.431	30.887	34.344	.144	1.728	124
8.519	10.269	12.018	13.767	15.516	17.266	20.764	24.263	27.762	31.260	34.759	.146	1.749	125
8.619	10.390	12.160	13.930	15.700	17.471	21.011	24.552	28.093	31.633	35.174	.148	1.770	126
8.721	10.512	12.303	14.095	15.886	17.678	21.260	24.843	28.426	32.009	35.592	.149	1.791	127
8.821	10.634	12.447	14.259	16.072	17.884	21.510	25.135	28.760	32.385	36.010	.151	1.813	128
8.924	10.758	12.591	14.425	16.259	18.093	21.761	25.429	29.097	32.764	36.432	.153	1.834	129
9.025	10.881	12.736	14.591	16.446	18.312	22.012	25.723	29.434	33.144	36.855	.155	1.855	130
9.128	11.005	12.881	14.758	16.635	18.511	22.265	26.018	29.772	33.525	37.278	.156	1.877	131
9.230	11.128	13.026	14.924	16.823	18.721	22.517	26.314	30.110	33.906	37.703	.158	1.898	132
9.334	11.254	13.173	15.093	17.013	18.933	22.773	26.613	30.453	34.292	38.132	.160	1.920	133
9.437	11.379	13.321	15.262	17.204	19.145	23.029	26.912	30.795	34.678	38.561	.162	1.942	134
9.541	11.504	13.467	15.431	17.394	19.358	23.284	27.211	31.138	35.065	38.992	.164	1.963	135
9.645	11.630	13.615	15.600	17.586	19.571	23.541	27.512	31.482	35.452	39.423	.165	1.985	136
9.749	11.757	13.764	15.771	17.778	19.785	23.799	27.813	31.828	35.842	39.856	.167	2.007	137
9.853	11.883	13.912	15.941	17.970	19.999	24.057	28.115	32.174	36.232	40.290	.169	2.029	138
9.959	12.010	14.061	16.112	18.164	20.215	24.317	28.420	32.522	36.624	40.727	.171	2.051	139
10.065	12.138	14.211	16.285	18.358	20.432	24.578	28.725	32.872	37.019	41.166	.173	2.073	140
10.171	12.267	14.362	16.578	18.554	20.649	24.841	29.032	33.224	37.415	41.606	.175	2.096	141
10.276	12.394	14.512	16.630	18.748	20.866	25.102	29.338	33.574	37.810	42.046	.177	2.118	142
10.383	12.523	14.663	16.804	18.944	21.085	25.365	29.646	33.927	38.208	42.489	.178	2.140	143
10.490	12.653	14.815	16.978	19.141	21.304	25.630	29.956	34.282	38.607	42.933	.180	2.163	144

Discharges in second-feet, reduced

	Head.		Length of weir.											
	Inches.	Feet.	4 in.	6 in.	9 in.	12 in.	15 in.	18 in.	24 in.	2 ft. 6 in.	3 ft.	3 ft. 6 in.	4 ft.	4 ft. 6 in.
145	9 1/16	0.755							4.040	5.133	6.226	7.319	8.411	[illegible]
146	9 1/8	.760							4.080	5.184	6.288	7.392	8.495	[illegible]
147	9 3/16	.765							4.120	5.235	6.351	7.466	8.581	[illegible]
148	9 1/4	.771							4.160	5.286	6.413	7.540	8.667	[illegible]
149	9 5/16	.776							4.199	5.338	6.476	7.614	8.753	[illegible]
150	9 3/8	.781							4.239	5.389	6.539	7.689	8.839	[illegible]
151	9 7/16	.786							4.280	5.441	6.602	7.763	8.925	[illegible]
152	9 1/2	.792							4.320	5.492	6.665	7.838	9.011	[illegible]
153	9 9/16	.797							4.360	5.544	6.729	7.913	9.097	[illegible]
154	9 5/8	.802							4.400	5.596	6.792	7.988	9.184	[illegible]
155	9 11/16	.807							4.440	5.648	6.856	8.064	9.272	[illegible]
156	9 3/4	.812							4.482	5.701	6.921	8.140	9.359	[illegible]
157	9 13/16	.818							4.522	5.754	6.985	8.216	9.447	[illegible]
158	9 7/8	.823							4.563	5.806	7.049	8.292	9.534	[illegible]
159	9 15/16	.828							4.604	5.858	7.113	8.368	9.623	[illegible]
160	10	.833							4.644	5.911	7.177	8.444	9.711	[illegible]

irs with end contractions—Continued.

Length of weir—Continued.											Addition for increase of length.		
5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.	1 in.	1 ft.	
0.597	12.782	14.967	17.153	19.338	21.534	25.894	30.265	34.636	39.007	43.378	0.182	2.185	145
0.704	12.913	15.121	17.329	19.537	21.745	26.161	30.577	34.994	39.410	43.826	.184	2.208	146
0.812	13.043	15.274	17.505	19.735	21.966	26.428	30.889	35.351	39.813	44.274	.186	2.231	147
0.920	13.174	15.428	17.681	19.935	22.188	26.696	31.203	35.710	40.217	44.724	.188	2.254	148
1.029	13.306	15.582	17.859	20.135	22.412	26.965	31.518	36.071	40.624	45.177	.190	2.277	149
1.138	13.438	15.737	18.037	20.336	22.636	27.235	31.834	36.433	41.032	45.631	.192	2.300	150
1.247	13.570	15.892	18.215	20.537	22.860	27.505	32.150	36.795	41.440	46.085	.194	2.323	151
1.356	13.702	16.048	18.393	20.739	23.084	27.776	32.467	37.158	41.849	46.540	.196	2.346	152
1.466	13.835	16.204	18.573	20.941	23.310	28.048	32.785	37.523	42.261	46.998	.197	2.369	153
1.576	13.969	16.361	18.753	21.145	23.537	28.321	33.105	37.890	42.674	47.458	.199	2.392	154
1.687	14.102	16.517	18.933	21.348	23.764	28.594	33.425	38.256	43.087	47.918	.201	2.415	155
1.798	14.237	16.676	19.145	21.553	23.992	28.870	33.747	38.625	43.503	48.380	.203	2.439	156
1.909	14.372	16.834	19.296	21.758	24.221	29.145	34.070	38.995	43.919	48.844	.205	2.462	157
2.020	14.506	16.992	19.478	21.963	24.449	29.421	34.392	39.364	44.336	49.307	.207	2.486	158
2.132	14.642	17.151	19.661	22.170	24.680	29.699	34.718	39.737	44.756	49.775	.209	2.510	159
2.244	14.777	17.310	19.843	22.377	24.910	29.976	35.043	40.109	45.175	50.242	.211	2.533	160

RAINFALL TABLES.

The following records of precipitation are arranged alphabetically by counties:

Record of precipitation at Tamarack, Alpine County.

[Latitude, 38° 37′; longitude, 119° 58′; elevation, 8,080 feet. Authority, P. C. Huntington.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Tot.
1898–1899							12.80	2.50	1.75	0.00	0.00	0.00	[illegible]
1899–1900	0.00	6.10	4.25	8.10	3.00	2.85	6.65	4.60	0.65	0.00	0.00	0.00	[illegible]
1900–1901	0.00	3.30	8.50	2.05	13.65	15.90	4.30	6.40	.95	0.39	T.	3.17	[illegible]
1901–1902	1.60	2.69	3.22	2.38	3.37	13.00	11.35	4.60	1.68	0.00	0.00	0.00	[illegible]
3-year mean													[illegible]

[a] Year incomplete.

Record of precipitation at Jackson, Amador County.

[Latitude, 38° 21′; longitude, 120° 45′; elevation, 1,975 feet. Authority, Richard Wells.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Tot.
1877–78	0	0.70	2.00	1.45	8.45	13.04	5.55	1.97	0.24	0.04	0	0	[illegible]
1878–79	0.05	.97	.86	.70	5.56	5.26	6.97	4.97	2.19	.25	0	0	[illegible]
1879–80	0	2.92	4.33	5.38	2.30	3.44	3.51	13.59	2.41	0	0	0	[illegible]
1880–81	0	.15	.60	10.47	8.86	4.77	2.11	2.96	0	.05	0	0	[illegible]
1881–82	.58	1.38	1.82	5.32	3.86	3.89	7.71	3.72	.49	.10	0	0	[illegible]
1882–83	.75	5.62	3.34	1.44	3.61	1.95	3.85	2.25	4.63	0	0	0	[illegible]
1883–84	.90	1.43	1.48	1.59	4.02	8.58	9.41	7.65	.99	1.85	0	0	[illegible]
1884–85	.26	1.70	.10	14.64	1.89	.27	.26	1.34	.15	.59	0	0	[illegible]
1885–86	.23	0	12.80	2.78	7.97	.75	4.54	8.04	0	0	.01	0	[illegible]
1891–92			1.08	8.03	3.21	3.03	4.89	2.70	3.85	.46	0		[illegible]
1892–93	.40		7.48	5.52						0	.04	0	[illegible]
1893–94	1.34	.50	5.28	3.35	9.88	10.84	2.52	1.38	4.15	1.48	T.	T.	[illegible]
1894–95	1.10	3.68	1.10	15.50	12.04	6.22	3.86	3.92	2.68	0	.07	T.	[illegible]
1895–96	1.14	.28	.98	3.67	8.79	.43	5.18	10.89	3.11	0	.04	[illegible]	[illegible]
1896–97	.23	1.35	8.78	4.61	4.77	5.04	7.66	1.46	.03	1.10	0	[illegible]	[illegible]
1897–98	.19	3.05	2.25	3.18	1.47	4.91	1.18	1.11	1.64	.43	0	0	[illegible]
1898–99	.40	1.04	2.11	2.70	5.20	.57	14.60	1.49	1.07	1.00	0	[illegible]	[illegible]
1899–1900	0	5.86	5.81	7.45	2.37	2.15	4.37	3.52	1.83	.06	0	0	[illegible]
1900–1901	.41	2.74	8.32	2.24	7.13	11.24	2.58	3.83	1.18	.08	T.	T.	[illegible]
1901–2	3.39	2.62	3.64	3.22	1.25	9.36	4.37	2.71	1.99	.15	0	T.	[illegible]
18-year mean					3.82								[illegible]

[a] Year incomplete.

Record of precipitation at Cherokee, Butte County.

[Latitude, 39° 38′; longitude, 121° 34′; elevation, 1,200 feet. Authority, L. Glass.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1-72	0	2.95	5.41	10.09	10.58	12.25	2.33	3.11	0.45	0.56	0	0	47.73
2-73	0	0	3.89	8.46	3.21	9.18	.59	2.14	.88	0	0	0	28.35
3-74	0	.94	5.03	16.48	9.79	6.74	7.36	3.57	1.58	.11	0	0	51.59
4-75	0	4.65	14.28	.43	10.84	.38	1.90	1.16	.66	1.04	0	0	35.34
5-76	0	.24	10.41	6.96	8.48	11.95	13.36	2.66	.23	0	1.19	0	55.48
6-77	.25	10.19	.....	.....	7.70	3.10	3.84	.75	1.51	1.28	.....	.....	[a]28.62
7-78	0	1.72	4.32	3.60	19.63	20.00	8.87	3.53	1.14	.60	.10	.45	63.96
8-79	1.52	2.09	2.39	.69	8.26	9.09	18.23	5.66	3.66	.35	0	.28	52.22
9-80	2.60	4.20	12.64	3.88	3.16	2.20	18.07	2.79	0	0	0	0	49.54
0-81	0	0	.42	16.84	14.95	7.31	2.34	1.49	1.16	0	0	0	44.51
1-82	.90	2.92	.39	6.79	4.04	8.32	6.47	4.59	0	0	0	0	34.42
2-83	1.31	3.23	4.65	3.72	1.42	1.31	8.10	3.12	6.98	0	0	0	33.84
3-84	0	5.21	1.06	1.17	6.69	6.16	11.89	9.27	.80	3.87	0	0	46.12
year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	45.26

[a] Year incomplete.

Record of precipitation at Cherokee Reservoir, Butte County.

[Latitude, 39° 38′; longitude, 121° 33′; elevation, 1,200 feet. Authority, L. Glass.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
3-74	0	0	5.80	18.25	13.07	8.15	10.78	4.83	1.08	0	0	0	61.91
4-75	0	5.99	16.99	1.15	12.47	.61	3.76	.10	1.10	2.00	0	0	44.17
5-76	0	1.00	15.20	11.26	11.08	13.08	15.94	3.48	1.00	0	1.00	.73	73.72
6-77	1.28	12.90	0	0	11.10	3.62	6.62	1.62	2.53	1.87	.80	0	42.34
7-78	0	2.22	5.70	3.98	23.54	24.00	12.01	4.98	1.67	0	0	.68	78.78
8-79	1.98	2.40	3.12	0	8.89	10.28	21.06	7.68	5.06	.50	0	0	60.97
year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	60.32

Record of precipitation at Fouts Springs, Colusa County.

atitude, 39° 20′; longitude, 122° 40′; elevation 1,659 feet. Authority, John F. Fouts and S. E. Stites.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb	Mar.	Apr.	May.	June.	July.	Aug.	Total.
5-86	(0.00)	0.20	19.43	4.85	9.29	2.00	1.65	5.01	0.50	T.	0	0	42.93
6-87	0	.70	.20	2.83	2.00	7.88	2.12	1.66	T.	T.	T.	0	17.39
7-88	T.	0	1.25	4.35	10.83	.70	5.00	(3.33)	2.14	0.65	(0.00)	(0.00)	28.25
2-93	.....	.....	.....	.....	2.08	7.11	5.17	1.95	.....	.....	.....	.....	[a]16.31
0-1901	.....	.....	.....	5.41	12.57	4.06	.....	.79	.....	.....	.....	.....	[a]22.83
year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	29.52

[a] Year incomplete.

Record of precipitation at Little Stony, Colusa County.

[Latitude, 39° 25′; longitude, 122° 30′; elevation, ——feet. Authority, C. M. Polley.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1884–85	.....	.....	.....	8.40	1.29	1.04	0	1.38	0	1.19	0	0	[illegible]
1885–86	0	0.27	13.29	3.51	3.44	0	1.10	3.89	.....	.....	.....	.....	[illegible]

[a] Year incomplete.

Record of precipitation at Mount Diablo, Contra Costa County.

[Latitude, 37° 53′; longitude, 121° 54′; elevation, 3,848 feet. Authority, Pacific Railway Survey, J. S. Hall.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1874–75	.....	.....	.....	.....	.....	0	0.68	T.	0.33	0.62	0	0	[illegible]
1875–76	0.00	0.18	9.19	3.11	5.60	4.95	6.23	0.65	(.39)	(.33)	.08	0	[illegible]
1876–77	T.	2.95	.27	0	4.63	1.89	1.11	.02	.45	.03	0	0	[illegible]
2-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]

[a] Year incomplete.

Record of precipitation at Eldorado, Eldorado County.

[Latitude, 38° 41′; longitude, 120° 51′; elevation, 1,609 feet. Authority, Pacific Railway Survey.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1888–89	.....	.....	.....	4.00	0.31	0.38	8.41	1.60	7.50	0.12	0	0	[illegible]
1889–90	0	7.46	6.32	14.94	12.48	5.67	10.04	3.00	3.45	0	0	.0[illegible]	[illegible]
1890–91	1.77	.10	0	5.48	1.07	6.93	6.71	3.52	.93	.95	0	0	[illegible]
1891–92	.00	.85	1.08	9.09	3.48	5.75	7.24	3.61	4.91	.15	0	0	[illegible]
1892–93	.08	2.04	7.80	10.33	5.40	2.58	8.02	3.13	1.51	0	0	0	[illegible]
1893–94	1.14	.65	4.58	4.26	8.74	11.90	2.25	1.63	3.98	1.00	0	0	[illegible]
1894–95	.67	3.52	1.05	14.37	14.25	4.18	3.94	4.06	2.34	0	0	0	[illegible]
1895–96	1.41	0	.78	3.79	13.82	.15	7.80	9.56	2.59	0	0	.08	[illegible]
1896–97	.41	1.00	9.49	3.62	3.51	4.50	7.63	1.65	.23	.55	0	0	[illegible]
1897–98	.17	2.54	2.21	2.88	1.43	2.19	.86	.53	2.67	.00	0	0	[illegible]
1898–99	.37	.95	2.45	2.70	4.60	.57	13.10	1.02	1.80	1.57	0	.16	[illegible]
1899–1900	0	7.18	6.19	6.73	3.87	1.99	5.15	3.40	1.70	0	0	0	[illegible]
1900–1901	.10	3.26	8.11	2.23	6.90	8.73	1.69	5.54	.89	0	0	0	[illegible]
1901–2	2.41	1.89	2.91	3.40	1.11	10.75	4.31	2.46	.82	.62	0	0	[illegible]
13-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]

[a] Year incomplete.

Record of precipitation at Georgetown, Eldorado County.

[Latitude, 38° 54′; longitude, 120° 50′; elevation, 2,500 feet. Authority, C. M. Fitzgerald.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
72-73	0	0	4.30	18.72	4.08	13.05	3.05	3.11	0.12	0	0.03	0	46.46
73-74	0	0.61	.55	16.60	16.66	8.03	13.87	5.80	1.32	.20	0	0	63.64
74-75	0	3.86	14.60	1.24	17.87	.04	5.07	.31	2.03	2.06	0	0	47.08
75-76	0	1.90	24.12	10.85	13.09	9.97	14.54	4.78	1.22	0	.77	0	81.24
76-77	0	11.47	.80	0	12.44	2.14	7.78	1.74	3.87	.24	0	0	40.48
77-78	0	1.03	4.30	1.97	16.21	22.78	10.92	2.99	.99	.12	0	0	61.31
78-79	.68	2.56	2.66	.48	11.24	12.41	17.57	9.65	3.39	.34	0	0	60.96
79-80	0	3.85	6.25	11.73	5.47	6.00	5.50	25.63	5.97	0	0	0	70.40
80-81	0	.18	.37	22.67	20.83	12.85	3.84	2.40	.40	2.28	0	0	65.82
81-82	2.03	4.23	3.30	10.32	8.59	5.88	10.44	7.11	2.06	.18	0	0	54.14
82-83	.16	7.75	7.00	3.31	4.70	3.08	8.73	3.87	7.34	0	0	0	45.94
83-84	1.60	4.10	1.94	3.50	7.53	13.80	19.94	15.07	1.52	3.65	0	.01	72.66
84-85	.80	3.54	.03	33.73	4.37	.82	.24	3.98	.19	2.28	03	0	50.01
85-86	1.16	0	20.77	7.03	18.32	1.16	7.75	15.04	1.76	.06	0	0	73.05
86-87	0	3.43	1.79	6.90	3.36	15.79	2.40	6.54	.93	.18	0	0	41.32
87-88	.53	0	1.44	7.66	14.21	3.14	6.02	1.18	.38	1.56	04	0	36.16
88-89	.41	0	4.67	7.99	.66	.68	12.29	2.77	7.07	25	0	0	36.79
89-90	0	10.45	1.23	22.94	19.90	8.96	14.70	3.86	4.66	.10	0	0	86.80
90-91	2.81	.19	T.	7.65	.06	10.39	10.00	3.79	2.71	2.22	.42	0	40.24
91-92	.17	1.80	1.59	3.74	5.48	8.44	7.90	7.47	7.58	38	T	0	44.55
92-93	.57	3.11	13.31	15.76	8.44	8.20	17.69	6.34	1.51	0	T	T.	74.98
93-94	2.06	1.60	10.94	7.19	13.89	16.25	4.74	2.40	5.25	1.61	T.	.20	66.13
94-95	1.26	6.22	1.53	20.93	20.52	7.69	4.67	4.77	4.30	0	.03	.07	71.99
95-96	2.64	.20	2.18	7.27	19.55	.77	11.28	16.51	4.81	0	.20	.10	65.51
96-97	.83	1.76	17.18	6.37	4.83	18.26	13.65	2.40	.20	1.00	0	.04	66.52
97-98	.30	4.25	4.09	5.57	2.13	8.83	1.80	92	2.78	1.23	0	T.	31.90
98-99	.53	2.22	4.34	3.35	8.59	.61	21.39	1.60	2.32	1.61	0	.14	46.70
99-1900	0	9.87	10.33	11.91	5.07	4.29	6.65	5.46	1.88	.13	.08	0	55.67
900-1901	1.00	5.49	8.99	4.16	10.40	13.70	2.78	6.48	.99	0	T.	T.	53.99
901-2	4.50	3.32	4.72	5.51	1.92	16 95	6.47	3.69	1.44	.56	0	.05	49.13
0-year mean													56.72

Record of precipitation at Placerville, Eldorado County.

[Latitude, 38° 44'; longitude, 122° 48'; elevation, 2,109 feet. Authority, G. M. Barlow and Pa[illegible] Railway system.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	To[illegible]
1873-74	0	0	0	0	12.58	4.72	10.77	3.92	1.96	0	0	0	[illegible]
1874-75	0	3.42	9.59	1.18	12.58	.08	2.88	.61	1.58	1.84	0	0	[illegible]
1875-76	0	1.20	17.64	6.75	10.79	8.01	11.86	3.60	1.40	0	0.49	0.05	[illegible]
1876-77	0.02	6.16	.78	0	10.54	1.17	0	4.00	0	0	0	0	[illegible]
1877-78	.66	.99	2.25	1.55	10.45	11.73	6.53	1.80	1.67	.05	.02	.02	[illegible]
1878-79	.52	1.50	2.04	.41	7.75	8.00	9.38	6.25	2.48	.33	.02	.02	[illegible]
1879-80	0	3.47	5.28	7.58	5.04	6.58	5.96	17.92	4.43	0	0	0	[illegible]
1880-81	0	.35	.58	16.94	15.53	7.01	3.38	2.36	0	1.89	0	0	[illegible]
1881-82	1.08	2.80	2.87	7.70	6.71	5.15	9.30	5.53	1.19	.13	0	0	[illegible]
1882-83	.93	5.72	4.94	1.98	3.74	2.58	6.88	3.54	6.25	0	0	0	[illegible]
1883-84	1.67	3.38	1.67	2.63	6.06	11.56	14.46	11.82	1.60	2.51	0	.06	[illegible]
1884-85	.85	2.47	.10	22.65	4.15	.97	.33	3.32	.27	1.42	0	0	[illegible]
1885-86	.55	0	15.97	5.22	13.03	1.15	5.22	11.75	1.24	.50	T.	0	[illegible]
1886-87	0	1.42	.91	5.02	3.18	14.18	2.09	5.71	.53	.28	0	0	[illegible]
1887-88	.58	.06	1.42	8.34	11.27	2.39	5.26	.91	1.10	1.50	.04	T.	[illegible]
1888-89	.88	T.	5.98	7.06	1.03	.86	9.78	1.93	8.05	.16	0	T.	[illegible]
1889-90	0	9.07	7.77	18.18	14.57	7.46	13.81	3.36	4.01	0	0	T.	[illegible]
1890-91	1.64	T.	T.	6.89	1.40	9.13	7.82	3.62	1.23	.85	.05	0	[illegible]
1891-92	.45	.50	1.48	12.57	4.43	6.83	8.26	4.33	5.35	0	0	0	[illegible]
1892-93	.20	2.23	12.14	15.48	7.94	7.52	12.29	4.83	1.34	0	T.	0	[illegible]
1893-94	1.40	.95	6.19	5.20	11.55	14.40	3.31	2.35	4.55	1.39	T.	0	[illegible]
1894-95	1.85	4.25	1.20	19.03	17.85	5.07	4.43	4.75	2.58	0	T	T.	[illegible]
1895-96	1.79	.16	.77	5.24	16.38	.78	11.11	12.00	3.56	0	.06	.15	[illegible]
1896-97	.63	1.51	11.71	4.47	4.68	14.61	9.49	2.23	.36	1.09	0	.05	[illegible]
1897-98	.13	3.39	2.68	2.43	1.78	6.18	1.28	.58	2.70	.66	T.	0	[illegible]
1898-99	.11	1.00	2.30	2.80	5.62	.48	14.98	2.01	1.78	.88	0	.10	[illegible]
1899-1900	0	7.73	6.72	8.32	3.92	2.89	5.84	4.32	1.15	.68	T.	0	[illegible]
1900-1901	.55	3.62	9.82	3.30	9.95	9.53	2.34	6.54	1.05	0	0	0	[illegible]
1901-2	3.13	2.12	3.74	3.58	1.35	10.15	5.33	2.73	1.35	.60	0	.14	[illegible]
29-year mean	[illegible]												[illegible]

Record of precipitation at Shingle Springs, Eldorado County.

Latitude, 38° 39′; longitude, 120° 55′; elevation, 1,427 feet. Authority, M. Phelps and Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
49-50	0	0.08	5.65	10.04	13.07	2.15	6.80	0.45	0.02	0	0	0	38.26
50-51	1.23	.10	.65	2.70	4.80	.40	2.10	4.80	.40	0	0	0	17.18
51-52	.40	.30	2.45	7.80	3.20	.50	9.60	7.25	1.00	0	0	0	32.50
52-53	0	.50	7.20	11.40	13.70	2.40	8.20	3.00	1.10	0.05	0	0	47.55
53-54	1.20	.75	6.40	4.10	4.40	3.40	4.30	5.40	.20	.30	0	0	30.45
54-55	0	3.72	2.70	3.50	3.20	1.10	2.50	2.10	.68	0	0	0	19.50
55-56	.70	0	2.40	5.70	4.10	.80	3.40	1.20	.20	.10	0	0	18.60
56-57	0	0	2.15	6.35	6.50	7.05	1.94	0	.42	.35	0.35	0	25.11
57-58	0	.42	4.04	1.99	2.37	2.69	4.00	1.70	.20	.60	0	0	18.01
58-59	0	3.25	.50	6.20	1.22	12.00	5.81	1.82	1.51	0	0	0	32.31
59-60	0	.15	11.16	2.40	2.20	1.15	4.71	3.40	2.10	.02	.80	0	28.09
60-61	0	1.20	.50	7.43	3.78	4.60	8.34	.20	.15	.05	0	0	26.25
61-62	0	0	6.90	11.22	34.13	6.75	6.90	7.34	4.10	1.90	2.56	0	81.80
62-63	0	.78	.37	2.84	1.45	4.98	4.01	2.76	2.10	0	0	0	19.27
63-64	0	0	2.05	6.30	7.29	3.21	.63	3.94	.85	0	0	0	24.27
64-65	0	.08	9.94	9.13	5.13	5.63	1.13	2.50	.89	0	0	0	34.43
65-66	0	.45	6.84	2.57	11.08	3.46	6.21	1.31	4.88	.18	0	0	36.98
66-67	0	0	4.73	18.77	9.17	7.51	4.09	6.01	.01	0	0	0	50.29
67-68	.82	2.24	7.17	23.76	12.12	3.70	14.39	.....	.....	.....	.....	.....	[a]64.20
85-86	.....	.....	.....	4.99	10.77	.69	3.84	9.51	.71	.....	.....	.....	[a]30.51
86-87	.....	1.66	.98	3.50	1.67	12.21	1.45	.....	.06	0	.....	.....	[a]21.48
87-88	.49	T.	1.08	6.18	8.82	1.08	4.22	.43	.18	.31	0	0	22.79
88-89	0	0	4.45	4.45	.40	.70	9.01	1.98	7.80	0	0	0	28.79
89-90	0	8.73	7.85	17.35	13.50	6.70	10.48	2.75	3.65	0	0	0	71.01
90-91	1.50	.08	0	5.40	1.40	7.65	7.97	3.80	1.60	.70	0	0	30.10
91-92	.04	.70	1.10	7.58	2.55	6.43	4.95	2.26	1.98	0	0	0	27.59
92-93	.15	2.30	7.85	8.25	4.97	4.17	9.78	2.95	.95	0	0	0	41.37
93-94	.85	.40	4.98	3.30	7.07	9.40	1.60	1.08	3.25	.25	0	0	32.13
94-95	0	3.55	.99	14.50	11.33	4.48	1.98	3.20	1.70	0	0	0	41.73
95-96	1.40	.15	2.53	3.56	14.07	.30	6.33	8.21	1.79	0	0	0	38.34
96-97	.25	1.05	11.75	7.18	4.25	12.75	7.00	.97	.22	.30	0	0	45.72
97-98	0	2.15	1.40	3.25	[illegible]	3.80	.05	.40	2.10	.52	0	0	14.60
98-99	.25	.80	1.90	3.05	4.87	.37	14.13	.60	1.28	1.25	0	.15	28.65
99-1900	0	6.25	6.29	7.30	.....	.....	.....	.....	.....	.....	.....	.....	[a]19.84
year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	33.46

[a] Year incomplete.

Record of precipitation at Jacinto, Glenn County.

[Latitude, 39° 35′; longitude, 122° 00′; elevation, 110 feet.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb	Mar.	Apr	May.	June.	July.	Aug.	Total.
92-93	0.62	1.21	6.32	8.13	4.20	2.99	3.71	0.87	1.44	0	0	0	29.49
93-94	.47	.06	2.67	1.61	4.50	1.47	.89	.51	1.24	0	0	0	13.42
94-95	1.20	1.33	.35	8.69	8.73	1.86	1 74	2.49	.22	0	0.36	0	26.97
95-96	2.33	0	1.10	.94	9.37	.24	2.92	4.03	.69	0	0	0.52	22.14
96-97	.68	.68	3.06	5.28	3.78	3.54	1.72	.77	60	0.44	0	0	20.50
97-98	0	2.12	1.16	1.40	.76	3.42	.31	2.07	0	0	0	0	11.24
98-99	.35	.41	0.49	1.39	6.36	0	4.29	.36	1.21	.53	0	0	15.39
99-1900	0	2.68	4.40	3.40	3.06	.17	1.27	1.68	.72	0	0	0	17.38
00-1901	0	2.42	5.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	[a]7.42
year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.57

[a] Year incomplete

Record of precipitation at Juliana, on Stony Creek, Glenn County.

[Latitude, 39° 35'; longitude, 122° 30'; elevation, 750 feet. Authority, Mrs. Lee Julian.]

Year	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1900-1901	.....	.....	.....	.....	.....	4.26	0.12	1.24	0.50	0	0	0	[illegible]
1901-2.	1.07	0.60	3.18	0.82	0.85	9.27	3.24	2.37	2.06	0	0	0	[illegible]

a Year incomplete.

Record of precipitation at Christmas Prairie, Humboldt County.

[Latitude, 40° 55'; longitude, 124° 00'; elevation, 3,000 feet. Authority, J. H. Blake.]

Year.	Sept.	Oct.	Nov.	Dec	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Total.
1883-84.	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.56	0.24	0.01	[illegible]
1884-85.	3.23	2.17	1.37	26.44	8.79	8.39	1.45	3.30	1.34	1.57	0	0	[illegible]
1885-86.	.93	1.65	31.99	18.85	16.59	6.30	6.51	12.97	2.83	0	1.17	0	[illegible]
1886-87.	0	4.72	3.93	13.73	15.97	20.92	5.00	.....	.....	.....	.....	.....	[illegible]
2-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]

a Year incomplete.

Record precipitation at Bishop Creek, Inyo County.

[Latitude, 37° 21'; longitude, 118° 22'; elevation, 4,450 feet. Authority, Pacific Railway Syste[illegible]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug	Total.
1883-84.	0.12	0.11	0	0.38	0.62	0.64	0.94	0.05	0	0	0	0	[illegible]
1884-85.	0	0	0	1.00	0	0	.67	.14	0	0	0	0	[illegible]
1885-86.	0	.02	0.35	0	1.03	0	.50	.38	0	0	0	0	[illegible]
1886-87.	0	0	0	.20	.65	1.58	0	.35	0.55	0.35	0	0	[illegible]
1887-88.	.15	.15	.05	1.10	1.37	.47	.05	0	0	.35	0.20	0	[illegible]
1888-89.	0	0	1.72	.40	.10	.50	1.46	.12	.30	0	0	0	[illegible]
1889-90.	0	.03	.35	1.20	4.75	.30	[illegible]	0	0	0	0	0.50	[illegible]
1890-91.	.69	0	0	1.00	0	3.70	.28	0	2.90	0	0	.03	[illegible]
1891-92.	.19	0	0	3.52	.10	.70	1.10	0	.25	T.	0	0	[illegible]
1892-93.	0	.20	1.42	2.27	1.22	1.12	.15	0	0	0	1.05	T.	[illegible]
1893-94.	.19	0	.10	.49	.30	.75	.09	.05	T.	.35	T.	.23	[illegible]
1894-95.	T.	0	0	1.18	1.10	.50	.22	.29	.15	.11	.21	.05	[illegible]
1895-96.	T.	.16	.15	T.	1.07	0	.60	.05	.03	0	.57	.03	[illegible]
1896-97.	.05	T	T.	.16	.32	1.67	1.75	0	.12	T.	.01	.05	[illegible]
1897-98.	.09	.39	T.	.49	.05	.13	T.	.21	.27	T.	T.	.05	[illegible]
1898-99.	.41	0	.21	.11	1.65	0	T.	.64	.02	0	0	.05	[illegible]
1899-1900.	0	.14	.05	1.05	.49	.01	.54	.60	.34	.12	T.	0	[illegible]
1900-1901.	.39	.03	2.69	.17	4.89	1.01	T.	.50	1.29	T.	0	.23	[illegible]
1901-2.	0	.81	.61	.12	.07	.55	1.53	.61	.06	0	T.	.12	[illegible]
19-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]

a Year incomplete.

Record of precipitation at Camp Independence, Inyo County.

[Latitude, 36° 50′; longitude, 118° 10′; elevation, 4,598 feet. Authority, United States War Department.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
65-66	.....	.....	0	0.65	2.42	0	0	0.16	.....	.....	.....	.....	[a]3.23
66-67	0	0.32	0	2.27	0	1.63	4.76	.53	0.76	0	0.01	1.15	11.43
67-68	0.07	.32	0.21	12.19	5.46	0	0	.40	.71	0	.10	0	19.46
68-69	0	.74	.44	1.17	.16	0	.32	.11	.36	0	.03	0	3.33
69-70	0	0	.14	0	.20	1.36	0	.21	.27	0	.35	.10	2.63
70-71	0	1.10	0	1.00	0	1.28	0	0	0	.30	0	0	3.68
71-72	0	0	.65	4.70	0	.30	.28	.55	.18	0	.28	.12	7.06
72-73	0	0	0	1.18	0	.40	0	0	0	0	0	.05	1.63
73-74	.10	0	0	3.40	2.40	1.00	0	0	0	.01	.15	0	7.06
74-75	.40	.80	.40	0	1.73	0	0	0	0	0	0	0	3.33
75-76	.01	0	.66	.62	1.51	.70	.87	0	0	.15	.19	.56	5.27
76-77	.16	.26	0	0	.76	0	0	.59	.69	0	0	0	2.46
91-92	.....	.....	.....	.....	.....	.....	.62	.....	.96	.07	T.	T.	[a]1.65
92-93	0	.35	.23	1.61	1.51	2.91	.98	.02	T.	0	.77	T.	8.38
93-94	T.	0	.10	.75	.12	.42	.09	.02	.10	.11	.12	.51	2.34
94-95	T.	0	0	1.89	1.24	1.18	.12	T	.01	T.	T.	.04	4.48
95-96	T.	.83	.67	.08	.....	.....	.....	.....	.....	.....	.....	.....	[a]1.58
96-97	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
97-98	.....	.....	.....	.....	.....	.....	0	.16	.23	T.	T.	.11	[a].50
98-99	.20	0	.10	.20	.54	T.	.01	.02	.03	.37	.01	.06	1.54
99-1900	T.	.30	.85	.56	.31	.05	.67	.62	.22	.04	.08	T.	3.70
00-1901	.75	.01	1.34	.13	2.81	.64	.05	T.	.36	0	.10	.32	6.51
01-2	0	.65	.22	.06	.04	1.69	1.05	.17	.04	.01	.17	.13	4.23
-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.47

[a] Year incomplete.

Record of precipitation at Keeler, Inyo County.

atitude, 36° 35′; longitude, 117° 50′; elevation, 3,622 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
83-84	.....	.....	.....	.....	.....	.....	.....	0.20	1.60	0.80	0	0.20	[a]2.80
84-85	0	0	0	0.70	0	0	0.12	.82	0	.08	0	.11	1.83
85-86	0	0.25	0.65	.36	0.49	0.14	.60	.40	0	0	.14	.08	3.11
86-87	0	.01	.08	0	T.	.93	0	1.14	.04	T.	.52	0	2.72
87-88	1.08	.84	.01	.48	.70	1.21	.30	.12	.30	.20	.17	.10	5.51
88-89	.06	0	1.68	.82	.04	T.	.52	.12	.06	.01	0	T.	3.31
89-90	.08	.56	.05	.56	.42	.01	T.	.10	.20	0	T.	1.71	3.69
90-91	.93	.03	.12	.22	0	1.00	2.01	0	.37	.30	.06	.02	5.06
91-92	.19	.04	0	.31	.26	.19	.32	0	.53	T.	0	0	1.87
92-93	T.	.81	.11	.54	.71	.75	1.50	0	T.	0	1.41	T.	5.83
93-94	T.	T.	.03	1.48	T.	.29	.01	T.	T.	T.	.11	0	1.92
94-95	0	0	0	1.05	.35	1.15	T.	.25	T.	T.	T.	T.	2.80
95-96	T.	0	0	T.	.45	0	T.	T.	.15	T.	.25	1.42	2.27
96-97	.50	T.	0	.25	.10	.27	.13	0	T.	0	0	.19	1.44
97-98	.14	.15	T.	T.	0	0	0	.05	0	0	0	0	.34
98-99	T.	0	T.	.30	.40	.45	0	.01	T.	.50	T.	T.	1.66
99-1900	0	T.	1.75	T.	T.	0	.16	1.25	.23	T.	.10	T.	3.49
00-1901	.35	.09	.45	0	.75	.25	0	T.	.40	0	0	.90	3.19
01-2	0	.50	0	0	T.	.25	1.25	0	0	0	T.	T.	2
-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.89

[a] Year incomplete.

Record of precipitation at Bear Valley, Kern County.

[Latitude, 35° 10'; longitude, 118° 30'; elevation, 4,000 feet. Authority, Philip Fickert, Tehachapi.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	To
1894-95	1.48	6.88	1.25	22.37	29.22	6.64	7.42	3.25	6.57	0	0.04	0.20	
1895-96	5.18	1.25	2.08	9.45	25.39	1.66	14.47	18.32	10.03	0	.72	.6	
1896-97	2.13	2.57	18.35	8.02	4.18	16.05	19.12	3.35	.80	.....	.....	.....	
1897-98	.....	.....	.....	5.96	3	10.44	.....	1.65	3.98	2	0	T.	
1898-99	.73	3.07	6.26	3.44	11.95	3.20	28.34	2.51	4	1.01	0	.8	
1899-1900	0	14.16	11.91	12.81	2.77	1.34	1	5.05	2.47	0	0	0	
1900-1901	0	1.76	2.71	.32	1.91	5.30	2.75	1.77	1.43	0	T.	0	
1901-2	0	1.27	.56	.90	3.20	5	5.36	3.48	.75	0	0	0	
6-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

[a] Year incomplete.

Record of precipitation at Caliente, Kern County.

[Latitude, 35° 17'; longitude, 118° 41'; elevation, 1,290 feet. Authority, Pacific Railway Syst

Year	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	To
1875-76	.....	.....	.....	.....	.....	2.02	1.66	0.53	T.	0	0	T	
1876-77	0	0.52	T.	0	1.08	.47	1.08	1.27	(0.52)	0	0	0	
1877-78	0	0	0.84	2.31	3.81	4.47	2.69	3.20	.03	0	0	0	
1878-79	0	.42	.10	.10	.20	.34	.33	1.43	.20	0.04	0	0	
1879-80	0	1.08	1.77	8.46	2.37	1.51	1.09	3.53	.23	0	0	0	
1880-81	0	0	0.35	3.56	1.61	1.54	1.91	.64	.23	0	0	0	
1881-82	0.13	0.81	.30	.51	1.51	3.30	.73	1.59	.69	.56	0	0	
1882-83	0	1.01	.69	.37	.04	1.76	.82	2.42	1.07	0	0	0	
1883-84	.08	.76	.05	(1.81)	2.00	4.98	5.00	2.90	1.10	1.28	0	0	
1884-85	0	.22	.25	3.25	.25	0	.45	3.00	1.05	0	0.05	0	
1885-86	0	.05	3.88	1.33	1.59	.66	2.62	2.65	0	0	T.	0	
1886-87	0	T.	1.45	1.33	.38	2.79	.07	2.66	.21	0	0	0	
1887-88	0	.68	.05	1.43	.87	1.14	1.50	0	.81	0	0	0	
1888-89	0	0	6.14	2.18	.59	.20	3.15	.60	0	0	0	0	
1889-90	0	1.35	1.05	3.65	(1.25)	1.15	1.10	0	1.62	0	0	0	
1890-91	.52	0	0	4.30	.19	2.83	.40	1.60	0	0	0	0	
1891-92	.27	.05	T.	3.73	.75	1.00	4.25	.30	1.00	.50	0	0	
1892-93	0	0	0	2.80	1.00	2.15	3.71	.70	0	0	0	0	
1893-94	0	.10	.20	3.45	3.30	1.40	1.60	.20	.50	.70	0	0	
1894-95	.60	.20	.25	4.39	5.28	3.10	1.67	.85	.87	0	0	0	
1895-96	0	2.31	1.51	1.20	2.53	.25	3.30	1.58	.56	0	.05	0	
1896-97	0	1.00	55	3.55	1.25	4.96	2.41	.35	.13	0	0	0	
1897-98	0	90	0	2.02	1.67	.70	1.45	.76	1.40	0	0	0	
1898-99	.10	0	.45	.68	1.73	.41	3.26	.28	1.13	0	0	0	
1899-1900	0	.25	1.52	.64	.50	.98	.80	1.75	2.35	0	0	0	
1900-1901	0	0	2.13	0	.89	2.10	.35	1.38	1.18	0	0	0	
1901-2	0	0	0	0	1.70	3.80	3.65	2.70	.11	(.12)	0	0	
26-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

[a] Year incomplete.

Record of precipitation at Fort Tejon, Kern County.

atitude, 34° 55′; longitude, 118° 44′; elevation, 3,945 feet. Authority, United States War Department, and J. G. Stitt, Bakersfield.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
54–55							1.58	3.78	0.61	0		0	[a]5.97
55–56	0.99	0.05	0	7.50	4.41	7.88	2.24	4.98	4.62	0	0	0.30	32.97
56–57	.08	.05	3.12	6.54	.37	.95	0	.04	.63	0	.07	.12	11.97
57–58	0	2.11	1.04	4.50	2.60	.75	7.39	5.37	.09	1.20	0	.35	25.40
58–59	.44	2.62	.25	3.07	.29	1.69	1.22	2.37	0	0	0	.07	12.02
59–60	8.58	.16	1.02	0	.22	.25	.20	.60	.20	.21	.01	.16	11.61
60–61					.73	.31	.26	T.	.43			T.	[a]1.73
61–62													
62–63												T.	
63–64	2.02	1.00	.71	4.32	.42	0	1.84	1.80	1.09	.04	T.	.10	13.34
64–95						3.08	2.14	1.44	1.31	0	0	0	[a]7.97
95–96	0	1.46	1.42	1.25	3.07	.40	4.01	3.33	2.05	.22	.26	.30	17.77
96–97	.53	1.63	1.74	4.47	3.52	5.14	3.63	.95	0	0	0	0	21.61
97–98	0	1.39	0	1.72	1.89	1.55	1.36	.40	.30	0	0	0	8.61
98–99	.60	0	.65	.73	2.57	.50	2.99	.55	.25	.78	0	0	9.62
99–1900	.05	1.10	1.71	1.40	2.12	.66	.85	1.82	1.57	0	0	0	11.28
00–1901	1.06	0	1.71	.50	1.80	5.86	1.97	.78	.90	0	0	T.	14.58
01–2	.05	1.61	.26	T.									[a]1.92
year mean													15.90

[a] Year incomplete.

Record of precipitation at Isabella, Kern County.

atitude, 35° 48′; longitude, 118° 25′; elevation, 2,600 feet. Authority, Stephen Barton, Isabella.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
95–96						0.10	1.93	0.89	0.04	0.06	2.57	0.01	[a]5.60
96–97	0.32	1.17	0.48	0.70									[a]2.67
97–98	.15	0	0	1.24	0.54	.99	.58	.06	.54	0	0	0	4.10
98–99	.04	0	0	.33	1.95	.19	1.89	.28	.25	.45	0	0	5.38
99–1900	0	.78	.85	.78	1.10	.65	.65	.73	1.06	0	0	.02	6.62
00–1901	.30	.24	5.53	.05	1.20	2.74	.33	.36	1.98	0	0	.99	13.72
01–2	0	.64	.13	0	.34	6.05	2.27	1.02	.05	0	0	0	10.50
year mean													8.06

[a] Year incomplete.

Record of precipitation at Keene, Kern County.

[Latitude, 35° 12′; longitude, 118° 40′; elevation, 2,705 feet. Authority, Pacific Railway ...

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	...
1877-78	0	0	0	1.75	4.37	7.49	2.72	2.10	0	0	0	0	...
1878-79	0	0.47	0	.74	.67	.55	.83	1.97	0	0	0	0	...
1879-80	0	.50	1.43	5.37	2.36	1.21	1.15	4.07	0.12	0	0	0	...
1880-81	0	.22	.26	3.43	2.12	2.42	1.96	.72	.19	0	0	0	...
1881-82	0.58	.21	.96	.30	1.40	2.57	1.42	1.44	.60	0.10	0	0	...
1882-83	0	1.40	.25	.47	.17	3.31	2.55	2.04	.86	0	0	0	...
1883-84	0	.45	.16	1.06	2.14	7.46	4.80	3.16	3.23	1.79	0	0	...
1884-85	0	2.55	.36	5.22	.30	.13	.65	1.47	.11	.10	0.06	T.	...
1885-86	0	.28	3.73	.46	2.02	.64	2.93	2.84	0	T.	T.	0.02	...
1886-87	0	T.	1.95	1.10	.51	3.20	.82	2.73	T.	.20	T.	...	...
1887-88	.12	1.32	.50	1.72	1.30	1.70	2.69	.78	2.03	0	.68	...	...
1888-89	0	0	1.28	2.29	.36	0	3.74	.95	1.77	0	0	...	...
1889-90	.42	2.23	1.30	5.17	3.15	1.97	1.98	.50	1.30	0	0	1.40	...
1890-91	.41	0	.10	3.57	.23	6.59	1.30	1.30	1.35	.05	0	0	...
1891-92	.22	0	.08	6.37	1.65	2.22	4.10	1.86	.60	1.07	0	0	...
1892-93	0	.16	.65	1.98	2.20	3.26	6.70	1.30	T.	0	1.05	0	...
1893-94	.14	.35	.18	1.50	3.60	1.65	2.25	.55	.40	.20	0	0	...
1894-95	.35	.05	.30	4.59	6.03	2.71	2.40	1.95	1.25	0	0	0	...
1895-96	0	1.37	1.65	1.90	.82	0	2.47	2.82	1.30	0	.15	.4	...
1896-97	0	0	1.01	2.94	2.28	7.49	3.17	.14	0	.59	0	0	...
1897-98	0	1.01	0	3.02	1.73	.75	2.04	.35	1.12	0	0	0	...
1898-99	.03	0	.40	.62	.41	1.17	4.10	.66	1.18	.79	0	0	...
1899-1900	0	.61	3.16	.90	.92	1.12	.54	2.57	1.55	0	0	0	...
1900-1901	.27	.70	1.94	0	.99	5.35	1.30	1.19	.80	0	0	.30	...
1901-2	0	.45	.26	.30	1.56	6 91	4.80	2.70	.45	0	0	0	...
25-year mean	...	...	...	...	...	...	...	...	...	...	...	...	...

Record of precipitation at Kernville; Kern County.

[Latitude, 35° 45′; longitude, 118° 27′; elevation, 2,600 feet. Authority, Stephen Barton Brown, Kernville.]

Year	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	...
1893-94	...	...	...	...	1.10	1.88	0.42	0.17	0.53	0	0	0.01	...
1894-95	0.60	0	0	5.31	5.10	1.55	1.80	.37	0	0	0	0	...
1895-96	0	0.50	0.95	.40	3.52	0	1.54	.86	0	0.20	2.25	.05	...
1896-97	0	1.48	.41	.85	3.40	3.60	2.57	.10	0	0	0	0	...
1897-98	0	45	1.14	11.32	.58	.99	.58	T.	.54	0	0	...	...
1898-99	.04	0	0	.33	1.25	.19	1.89	.28	.25	.45	0	0	...
1899-1900	0	.78	.85	73	.80	.53	.58	.52	90	0	0	0	...
1900-1901	.79	.10	5.09	0	1.35	2 92	.15	.31	1.62	0	0	70	...
1901-2	0	.72	.15	0	.30	3.07	2.10	.74	.10	.00	.00	00	...
7-year mean	...	...	...	...	...	...	...	...	...	...	...	...	...

[a] Year incomplete.

Record of precipitation at Mount Breckinridge, Haulon, Kern County.

[Latitude, 35° 25′; longitude, 118° 35′; elevation, 6,750 feet Authority. G. Otterman.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr	May.	June.	July.	Aug.	Total.
-97			2.26	5.95	2.70	5.12	7.72	0	0.40	0.10	0	0	[a]24.25
-98[b]													
-99						1.79	3.17						[a]4.96

[a] Year incomplete. [b] No record kept in 1898.

Record of precipitation at Taylor's ranch, Weldon, Kern County.

titude, 35° 31′; longitude, 118° 17′; elevation, 2,640 feet. Authority, Geo. E. Carleton and Annie Alexander, Weldon.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
-1900			0.78	0.66	0.71	0.47	0.50	0.39	0.82	0.02	0	0.03	[a]4.38
-1901	0.62	0.02	4.29	0	1.06	1.96	.05	.41	1.02	0	0	2.60	12.03
-2	0	.39	.12	0	26	4.37	1.41	.31	0	0	0	0	6 86
ar mean													9.45

[a] Year incomplete.

Record of precipitation at Tehachapai, Kern County.

titude, 35° 06′; longitude, 118° 26′; elevation, 3,964 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr	May	June.	July.	Aug.	Total.
-77	0.08	0.45	0	0	0.58	0.14	0.89	0.60	0.12	0	0.02	0	2.88
-78	0	T.	0.50	2.91	2.59	6.32	1.76	1.93	.28	0.09	0	T.	16 38
-79	0	.30	.04	.64	2.62	.45	.19	1.39	.09	.12	0	0	5.84
-80	0	.52	1.03	5.52	2.81	1.94	1.47	2.30	0	0	0	0	15.59
-81	0	.75	.10	2.14	1.79	2.05	3.15	.50	0	0	0	0	10.48
-82	.32	.10	.50	.12	1.05	2.07	1.45	.63	.20	.15	0	0	6.59
-83	0	.74	.18	.50	15	4.55	1.51	2.89	1.73	0	0	0	12.25
-84	0	.81	.14	.72	1.54	7.57	3.48	1.85	1.26	1.05	0	0	18.42
-85	0	.13	29	3 96	.10	0	.26	1.48	.30	0	.05	.31	6.88
-86	0	0	3.70	.52	1.58	6.06	4.10	4.57	0	0	.10	0	20.63
-87	0	T.	1.15	.60	.50	8.88	.24	1.95	.26	0	0	0	13.58
-88	0	.86	.26	1.44	2.57	2.60	1.20	1.25	.25	0	0	0	10.43
-89	0	0	0	3.65	.40	.60	3.56	3.96	1.07	0	0	80	14.04
-90	0	2.70	.70	5.30	1.75	.70	.30	0	0	0	0	0	11 45
-91	.50	0	0	3.48	.03	3.45	.80	.90	.70	(0.00)	0	0	9.86
-92	1.17	0	0	3.10	.92	2.68	2.72	.61	.55	0	0	0	11 75
-93	0	0	0	.40	85	3.61	5.00	.65	0	0	0	0	10.51
-94	0	.50	.50	5.25	2.80	1.68	0	(.18)	.32	.27	0	0	11.50
-95	.10	0	0	3.75	3.21	.69	1.08	.50	75	0	0	0	10.08
-96	0	.44	60	.26	1.57	0	2.80	.63	0	0	0	.85	7.15
-97	0	1.45	.53	1.13	1.78	2.03	.18	.25	0	0	0	0	7.35
-98	.02	.38	0	1.00	1.20	.34	1.35	.10	.82	0	0	0	5.21
-99	0	0	T.	.20	.68	.30	1.02	0	.22	.38	0	0	3.70
-1900	0	.57	1.53	.61	.64	.30	.29	1.20	.50	23	T.	0	6.05
-1901	0	.46	1.53	0	1.17	3.29	.25	.26	79	0	0	1.70	9.47
-2	0	.50	0	0	.80	3.90	1.05	1 73	0	0	0	0	7.98
year mean													10.28

Record of precipitation at Tejon Ranch, Kern County.

[Latitude, 35° 01′; longitude, 118° 45′; elevation, 1,450 feet. Authority, R. M. Pogson, Bakers

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	T
1894-95					5.05	1.39	1.70	1.11	.49	0	0	0	
1895-96	0	2.13	1.41	1.06	1.90	.37	4.22	1.62	.48	0	0	0	
1896-97			2.12										
1897-98					2.32	1.68	.94	.17	.84	0	0	0	
1898-99	0.34	.42	.57	.87	1.30	2.10	4.03	.82	0	0	0	0	
1899-1900	0	1.31	1.82	1.67	1.17	.35	.41	1.97	1.57	.02	0	0	
1900-1901	06	67	1.06	.34	1.28	4.69	.95	1.36	1.28	0	0	T.	
1901-2	0	.40	.17	.60	1.61	1.46	2.74	2.02	.98	0	0	0	
5-year mean													

a Year incomplete.

Record of precipitation at Bartlett Springs, Lake County.

[Latitude, 39° 10′; longitude, 122° 45′; elevation, 2,375 feet. Authority, J. E. McMahon

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	T
1896-97					3.50	6.78	5.36	0.75	0	0	0	0	
1897-98	0	1.70	2.31	3.72	1.53	8.36	.19	.63	2.39	1.10	0	0	
1898-99	0	0	1.87	1.23	13.14	0	8.49	85	2.47	0	0	0	
1899-1900	0	4.79	10.06	7.87	7.51	1.27	6.42	3.23	.88	0	0	0	
1900-1901					14.59	7.62	1.67	4.52	1.40	0	0	0	
1901-2	1.17	1.80	5.86	4.02	1.71	22.38	5.98	5.20	3.40	0	0	0	
4-year mean													

a Year incomplete.

Record of precipitation at Kono Tayee, Lake County.

[Latitude, 39° 5′; longitude, 122° 43′; elevation, 1,360 feet. Authority, R. S. Floyd

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	T
1873-74	0	0	0	0	1.88	3.60	4.62	2.05	0.45	0	0	0	
1874-75	0	3.70	6.25	0.29	9.16	.38	.92	0	.84	0.42	0	0	
1875-76	0	1.17	6.98	5.12	6.05	4.22	8.34	.10	0	0	0	0	
1876-77	0	.20	3.50	0	3.17	2.81	1.40	.50	0	.50	0	0	
1877-78	0.73	1.65	2.23	1.98	14.16	11.04	4.60	1.43	0.79	.45	0	0	
1878-79	0	.41	1.37	.33	3.01	3.41	9.15	.47	.64	0	0	0	
1879-80	0	.91	3.57	5.72	6.24	3.85	4.74	.48	.25	0	0	0	
1880-81	0	0	3.54	1.92	5.50	6.58	.64	.95	.12	.25	0	0	
1881-82	0	.63	2.90	1.77	1.74	3.20	2.34	1.54	.40	0	0	0	
1882-83	.42	1.64	4.42	.98	1.40	.60	3.81	.95	2.41	0	0	0	
1883-84	.70	.99	.39	.70	4.17	1.91	5.35	3.88	.06	4.08	0	0	
1892-93	.18	.84	6.53	5.57	3.84	4.15	5.41	2.06	.66	0	0	0	
1893-94	.25	.42	3.76	2.34	6.92	4.32	1.11	.91	.90	1.64	0	T	
1894-95	.50	1.22	.74	10.70	14.45	2.32	3.13	.98	1.14	0	0	T.	
1895-96	.71	0	1.69	2.12	9.42	.25	2.31	4.62	1.69	.45	T.		
1896-97	.29	.73	3.33	5.93	2.85	4.01	3.76	.90	.90	.48	0	0	
1897-98	0	1.24	1.64	2.12	.71	4.19	.11	.64	1.67	.45	0	0	
1898-99	.51	.46	1.15	1.27	7.74	T.	5.43	.70	.45	.28	.18	T.	
1899-1900	0	3.78	5.56	4.14	3.10	1.27	2.89	2.32	.67	T.	0	0	
1900-1901	T.	3.11	3.89	1.67	5.57	4.33	1.33	2.05	.96	.45	0	T.	
1901-2	.54	1.04	3.87	1.19	1.31	10.28	3.85	2.42	1.59	0	0	T	
21-year mean													

Record of precipitation at Lakeport, Lake County.

[Latitude, 123° 0′; longitude, 39° 0′; elevation, 1,325 feet. Authority, D. C. Rumsey.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Total.
1901.....	0	4.25	5.55	4.20	9.20	3.95	1.25	2.15	0.62	0	0	0	31.17
2.....	.88	2.20	4.18	0	3.00	12.86	3.70	3.30	2.45	0	0	0	32.57
ar mean.....													31.86

Record of precipitation at Middletown, Lake County.

[Latitude, 38° 46′; longitude, 122° 37′; elevation, 1,300 feet. Authority, Leon Lake.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
80.....	0.91	1.36	8.38	9.59	7.07	2.48	4.64	22.21	1.76	0	0	0	58.40
81.....	0	0.06	0.02	21.86	17.85	5.95	1.83	2.52	0.29	0.34	0	0	50.72
82.....	.55	1.26	1.05	8.09	2.86	6.80	4.60	2.57	.65	0	0	0	28.43
83.....	.90	2.93	5.07	1.47	2.25	1.92	7.25	3.69	3.97	0	0	0	29.45
84.....	2.55	1.36	.57	2.34	8.25	5.25	12.82	8.36	.06	3.28	0	0	44.84
85.....	.50	2.08	.05	22.93	2.54	1.37	12.82	8.42	.30	2.98	0	0	53.99
86.....	.15	.54	19.42	6.60	13.61	0.32	0.70	1.32	0	.27	0	0	42.93
87.....	.....	.....	.....	3.96	2.25	10.74	1.71	8.03	1.64	0	.....	.....	a 28.33
93.....	.91	2.05	15.64	14.77	6.25	7.82	9.32	3.88	1.49	0	0	0	62.13
94.....	.78	.36	3.06	3.36	14.37	8.32	2.09	2.65	2.06	.89	0	0	37.94
95.....	1.28	3.18	1.92	20.52	28.90	3.40	5.87	1.77	1.75	0	0.10	0	68.69
96.....	1.88	0	3.06	5.59	25.78	.06	5.79	8.54	2.23	0	.01	0.10	53.02
97.....	.48	1.10	7.55	11.21	.....	.....	.....	.....	.....	.....	.....	.....	a 20.34
ear mean.....													48.23

a Year incomplete.

Record of precipitation at Susanville, Lassen County.

[Latitude, 40° 23′; longitude, 120° 35′; elevation, 4,195 feet. Authority, T. B. Sanders.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
5-86.....	0.71	0.50	5.92	3.23	4.27	0.92	2.70	1.70	1.28	1.22	0.57	0.30	23.32
6-87.....	.....	1.32	.....	2.23	.....	5.57	.....	.....	.....	.....	.....	.....	a 9.12
7-88.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8-89.....	.71	.01	1.45	1.89	.03	.60	4.81	1.07	6.26	1.55	.05	0	18.43
9-90.....	0	4.18	2.74	8.55	8.72	4.71	4.60	1.06	1.51	.14	0	.15	36.36
0-91.....	.15	T.	.35	3.47	1.00	7.84	2.49	.80	2.41	1.65	.55	T.	20.71
1-92.....	.65	.45	1.10	4.91	1.77	2.96	2.80	2.80	1.35	.98	0	0	19.77
2-93.....	.71	.83	10.66	6.80	4.82	3.53	1.55	1.83	.67	0	T.	T.	31.40
3-94.....	1.65	.60	1.80	.95	6.10	3.53	2.35	.95	1.55	.75	0	.20	20.43
4-95.....	.30	1.96	.40	8.66	10.29	3.00	1.26	.50	1.50	T.	T.	.20	28.07
5-96.....	3.00	.10	1.95	2.91	6.94	.05	3.23	5.10	2.22	T.	.20	.20	25.90
6-97.....	1.33	.50	3.88	2.96	5.99	4.25	2.60	.30	.90	.42	0	.08	23.21
7-98.....	.55	2.65	3.13	2.22	.45	2.38	.35	.24	.54	1.02	0	.08	13.61
8-99.....	.10	.80	1.74	.65	2.90	.31	3.32	.92	1.42	0	0	.46	12.62
9-1900.....	0	5.21	2.70	3.59	1.50	1.22	2.97	.90	.64	.40	.63	.02	19.78
0-1901.....	.25	2.67	3.29	2.00	4.76	3.17	1.50	1.57	.92	.27	0	1.77	22.17
1-2.....	.59	2.28	1.72	1.89	.70	5.14	2.56	1.31	.35	0	.54	.09	17.17
year mean.....													22.20

a Year incomplete.

Record of precipitation at Azusa, Los Angeles County.

[Latitude, 34° 8′; longitude, 117° 54′; elevation, 630 feet. Authority, H. F. Parkinson.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1897-98	0	4.25	0.25	T.	1.75	1.25	0.81	0.25	2.63	T.	T.	0	[illegible]
1898-99	.06	T.	T.	0.50	2.81	T.	2.49	T.	T.	1.25	0	T.	[illegible]
1899-1900	T.	2.55	1.79	1.00	1.31	T.	1.71	1.05	2.79	0	0	0	[illegible]
1900-1901	.13	.34	10.25	0	3.77	4.86	.50	.73	1.91	T.	T.	T	[illegible]
1901-2	T.	2.35	.67	T.	2.24	2.84	3.99	.38	.18	.08	T.	0	[illegible]
5-year mean.													

Record of precipitation at Calabasas, Los Angeles County.

[Latitude, 34° 09′; longitude, 118° 39′; elevation, 925 feet. Authority, J. G. Chapman.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1901-2				0	1.28	4.35	2.17	0	0	0	0	0	[illegible]

Record of precipitation at Colby's Camp, Los Angeles County.

[Latitude, 118° 05′; longitude, 34° 15′; elevation, 3,875 feet. Authority, D. W. Colby, Pasa[illegible]]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1898-99					2.90	0.25	2.75	0.17	0.60	0.79	0	[illegible]	[illegible]
1899-1900	0	3.66	1.25	1.26	1.15	0	2.00	1.38	3.25	0	0	[illegible]	[illegible]
1900-1901	0.25	.45	8.15	0	6.94	13.54	.67	2.65	1.10	.10	0	0.5	[illegible]
1901-2	.10	3.15	0	0	2.50	3.15	3.55	1.84	.20	.10	0	[illegible]	[illegible]
3-year mean.													

[a] Year incomplete.

Record of precipitation at Follows Camp (Azusa), Los Angeles County.

[Latitude, 34° 14′; longitude, 117° 49′; elevation, 1,800 feet. Authority, R. M. Follows, Azusa.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1896-96				1.02	2.77	T.	6.55	0.70	0.36	0	0.07	[illegible]	[illegible]
1896-97	T.	2.95	1.03	1.61	5.43	10.39	8.25	.15	.28	T.	0	[illegible]	[illegible]
1897-98	.45	7.85	.20	.27	0	9.80	0	.85	6.16	1.03	0	[illegible]	[illegible]
1898-99	0	0	1.70	.70	3.59	.84	2.49	.12	0	.91	0	[illegible]	[illegible]
1899-1900	.12	3.03	1.64	.44		T.	2.40	1.77	2.98				
1901-2			.80	15									
3-year mean.													

[a] Year incomplete.

Record of precipitation at La Liebre, Los Angeles County.

atitude, 34° 46′; longitude, 118° 40′; elevation, 3,170 feet. Authority, J. W. Forbes, Neenack.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
-97	.....	.....	.....	.....	3.67	4.01	2.30	0.10	.....	.....	.....	.....	a 10.08
-98	.....	0.50	.....	0.40	.53	.38	.81	0	0.45	0	0	0	a 3.07
-99	0.20	0	0	.66	1.79	.04	2.26	.09	.04	0.27	0	0	5.35
-1900	.05	1.47	0.90	.46	1.24	.....	.....	.....	.....	.....	.....	.....	a 4.12

a Year incomplete.

Record of precipitation at Los Angeles, Los Angeles County.

titude, 34° 03′; longitude, 118° 15′; elevation, 330 feet. Authority, Signal Service and Weather Bureau.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
-72	.....	.....	.....	.....	.....	2.25	0.43	0.97	0.10	0	0	0.22	a 3.97
-73	0	0	0	4.42	2.08	7.19	.05	0	0	0	0	1.06	14.80
-74	0	0	0.74	5.74	5.51	9.77	1.09	.45	.42	0	0	0	23.72
-75	0.06	1.81	1.89	.20	17.22	.15	.22	.07	.05	0	0	0	21.67
-76	0	0	7.57	.82	6.54	7.92	3.41	.45	.03	0	0	0	26.74
-77	0	40	0	0	3.48	.01	.83	.26	.30	0	0	0	5.28
-78	0	86	.45	3.93	3.33	7.68	2.57	1.71	.66	0.07	0	0	21.26
-79	0	.14	0	4.70	3.50	.97	.49	1.19	.24	.03	0	0	11.35
-80	0	93	3.44	6.53	1.33	1.56	1.45	5.06	.04	0	T.	T.	20.34
-81	0	.14	.67	8 40	1.43	.36	1.66	.46	.01	0	0	T.	13.13
-82	T.	.82	.27	.52	1.01	2 66	2.66	1.83	.63	T.	0	0	10.40
-83	T.	.05	1.82	.08	1.62	3.47	2.87	.15	2.02	.03	T.	0	12.11
-84	0	1.42	0	2.56	3.15	13.37	12.36	3.58	.39	1.39	0.02	.02	38.26
-85	T.	.39	1.07	4.65	1.05	.01	.01	2.01	.06	T.	T.	T.	9.25
-86	.05	30	5.55	1.65	7.78	1.41	2.52	2.32	,01	.11	.27	.21	22.18
-87	.11	.02	1.18	26	.20	9.25	.29	2.36	.20	.07	.07	T.	14.01
-88	.18	.17	.80	2.68	6.04	.80	3.17	.12	.05	.01	.04	.10	14.16
-89	.03	.40	4.02	6.26	.25	.92	6.48	.27	.65	.01	T.	.28	19.57
-90	.34	6.96	1.35	15.80	7.83	1.36	.66	.22	.03	.02	0	.03	34.60
-91	.06	.03	.13	2.32	.25	8.56	.41	1.26	.31	0	T.	0	13.33
-92	.06	0	0	1.99	.88	3.19	3.39	.22	2.06	.06	0	.01	11.86
-93	0	.33	4.40	4.18	6.29	2.27	8.52	19	.06	.03	0	0	26.27
-94	T	.75	.20	3.65	.94	.49	.37	.13	.20	T.	T.	.01	6.74
-95	.73	.02	0	4.62	5.84	.46	3.77	.46	.19	01	T.	T.	16.10
-96	T	.24	.80	.78	3.23	T.	2.97	.19	.30	T.	.02	.01	8.54
-97	T	1.30	1.66	2.12	3.70	5.62	2.31	.02	.10	T.	T.	0	16.83
-98	0	2.47	.01	05	1.26	.51	.98	.03	1.75	T.	.07	T.	7.13
-99	02	.09	T.	.12	2.64	.04	1.81	.18	.04	.58	0	.01	5.53
-1900	T.	1.59	.90	.90	1.17	T.	.99	.54	1.81	T.	T.	T.	7.90
-1901	T	.26	6.53	T.	2.49	4.38	.45	.68	1.50	T.	T.	.09	16.38
-2	.03	1.88	46	0	1.62	3.35	2.98	.16	.03	T.	0	0	10.51
ear mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16.00

a Year incomplete.

Record of precipitation at Magic Hill, No. 1, Los Angeles County.

[Latitude, 34° 23′; longitude, 118° 22′; elevation, 2,820 feet. Authority, B. L. Hutchins, Burbank.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1897-98	.....	.....	0.10	0.30	0.25	0.61	0	0.34	0.29	1.80	1.35	0.2
1898-99	3.12	.....	.....	.....	1.60	.15	2.07	.14	1.65	.05	0	0
1899-1900	.07	2.25	1.07	1.20	1.34	0	1.67	2.05	4.40	.06	.04	0
1900-1901	.54	.71	6.53	0	6.71	6.68	.78	1.79	.57	.....	.....	.....

[a] Year incomplete. [b] Record stopped.

Record of precipitation at Manzana, Los Angeles County.

[Latitude, 34° 45′; longitude, 118° 35′; elevation, 2,850 feet. Authority, E. A. Sibley.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1893-94	.....	.....	.....	.....	0.21	0.37	0.36	T.	0.35	0.17	0	0.1
1894-95	0.49	0	0	3.60	2.79	0	1.36	0.08	T.	0	0	0
1895-96	0	0.40	0.48	.18	1.09	0	1.70	.63	T.	0	0	.1
1896-97	0	.61	.30	1.46	2.70	3.04	1.71	.04	.01	T.	T.	.3
1897-98	0	.21	T.	.14	.63	.02	.47	0	.24	0	0	0
1898-99	T.	0	0	.50	1.15	T.	1.35	.04	.09	.04	0	0
1899-1900	0	1.27	.71	.29	1.11	.10	.93	.42	.38	0	0	.0
1900-1901	.10	.09	2.55	0	3.20	6.68	.25	.61	.12	0	0	.6
1901-2	T.	2.02	.20	T.	.67	1.52	1.14	0	.15	T.	0	0
8-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

[a] Year incomplete.

Record of precipitation at Mount Lowe (Echo Mountain post-office), Los Angeles County.

[Latitude, 34° 15′; longitude, 118° 07′; elevation, 3,200 feet. Authority, Louis Swift and Elsie Larkin.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1895-96	.....	.....	.....	1.35	2.85	0.10	4.10	0.60	0.30	0	0	
1896-97	0	2.39	1.55	2.17	6.42	7.47	6.67	.19	.87	0.10	0.15	
1897-98	0	2.57	.40	.22	1.55	2.22	1.65	2.70	2.17	0	0	
1898-99	0.25	.30	0	.98	3.29	0	3.40	.20	1.90	.40	0	
1899-1900	0	3.00	2.85	.....	.....	.....	2.90	2.15	4.05	.40	T.	
1900-1901	.25	1.66	11.71	0	7.55	5.42	1.18	1.14	4.45	.75	0	
1901-2	0	4.18	1.05	.23	1.88	3.48	5.97	1.35	.33	.30	0	
5-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

[a] Year incomplete.

Record of precipitation at Mount Sister Elsie, Los Angeles County.

[Latitude, 34° 17′; longitude, 118° 14′; elevation, 5,021 feet. Authority, L. T. Rowley, Monrovia.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1898-99	.....	.....	.....	.....	2.95	0.12	3.37	0.58	0.08	0.78	0	0
1899-1900	0.35	2.10	1.34	0.41	.85	0	1.87	1.30	3.02	0	0	T.
1900-1901	.09	.81	6.70	0	8.92	12.13	.95	3.60	1.98	.....	.....	.....

[a] Year incomplete. [c] Record discontinued.

Record of precipitation at Newhall, Los Angeles County.

titude, 34° 25'; longitude, 118° 33'; elevation, 1,268 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
-77	0	0	0	0	1.56	T.	0.43	0.60	0.56	0	0	0	3.05
-78	0	0.03	0.32	1.45	3.78	3.23	1.02	1.46	.15	0	0	0	11.44
-79	0	0	0	2.33	2.25	.62	0	1.52	.05	0	0	0	6.77
1-80	0	.37	3.10	9.23	.10	2.25	1.08	3.39	0	0	0	0	19.52
1-81	0	0	.26	6.22	.57	.06	1.70	.34	0	0	0	0	9.15
-82	0	1.23	.12	4.21	.43	2.36	4.71	.93	0	0	0	0	13.99
1-83	0	.16	1.20	0	1.96	2.95	3.07	0	2.28	0	0	0	11.62
1-84	0	.16	0	3.34	6.66	14.53	9.73	3.85	2.17	1.67	0	0	42.11
1-85	0	.60	1.10	3.89	.47	0	.07	1.75	0	.06	0.02	0	7.96
1-86	0	0	9.01	2.25	5.22	.69	3.11	4.27	0	T.	0	0	24.55
1-87	0	0	.87	.21	0	12.38	.15	1.96	.10	.03	0	0	15.70
7-88	0.02	.65	1.46	4.26	6.74	1.17	4.21	.29	.04	0	0	0	18.84
3-89	0	.40	3.69	5.64	.35	(.08)	9.39	.40	.56	0	0	0.36	21.59
3-90	0	(2.50)	3.36	15.70	0.30	4.41	.44	.31	(0.00)	0	0	0	33.04
0-91	.35	0	0	1.94	.31	9.99	.88	1.26	.66	0	T.	0	15.39
1-92	.13	0	0	2.12	1.32	3.02	4.07	.06	2.08	0	0	0	12.80
2-93	0	.30	4.72	4.16	3.91	1.34	7.90	.47	.34	0	0	0	23.14
3-94	0	.72	0	3.90	.85	.29	.62	.15	.66	0	0	0	7.19
4-95	.80	0	0	7.59	7.11	.31	3.66	.39	0	0	0	0	19.86
5-96	0	.10	1.09	.11	2.15	.15	4.04	1.03	.20	0	0	.25	9.12
6-97	0	1.55	1.00	2.23	4.86	5.08	3.32	0	.08	0	0	0	18.12
7-98	0	1.00	0	0	.45	3.14	0	.10	.93	0	0	0	5.62
8-99	.14	0	0	.22	2.77	0	1.98	.08	0	.25	0	0	5.44
9-1900	0	1.63	.90	.64	.89	0	1.97	.25	1.31	0	0	0	7.59
0-1901	0	.08	5.24	0	5.13	6.14	.13	.74	1.62	0	0	0	19.08
01-2	.10	2.32	.70	0	1.00	2.90	2.53	.34	0	0	0	0	9.89
year mean													15.10

NOTE.—February and October, 1889, and May, 1890, estimated by War Department.

Record of precipitation at Palmdale (Headworks), Los Angeles County.

[Latitude, 34° 25'; longitude, 118° 03'; elevation, 3,299 feet. Authority, Burt. Cole and S. T. Berkley.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
95-96	T.	T.	0.75	0.10	1.00	T.	2.50	T.	0	0	0.25	1.35	5.95
96-97	0.32	1.42	.43	.98	3.78	3.71	1.31	0.04	0.32	0	.03	1.57	13.91
97-98	T.	.86	0	.14	2.38	.07	.90	0	.21	0	.02	.05	4.63
98-99	0	0	T.	.87	1.00	.31	.97	0	0	0	0	0	3.15
99-1900	0	1.28	.27	.32	.65	0	.80	.57	.76	0	0	0	4.65
00-1901	0	.20	1.79	0	1.34	4.50	.38	.15	T.	0	0	.33	8.69
01-2	T.	.32	.04	0	1.17	1.08	1.96	.20	0	T.	0	0	4.77
year mean													6.86

Record of precipitation at San Fernando, Los Angeles County.

[Latitude, 34° 16′; longitude, 118° 28′; elevation, 1,066 feet. Authority, Pacific Railway ...]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	T...
1877-78	0	0.04	0.48	2.36	4.15	6.89	2.08	2.55	0.36	0	0	0	...
1878-79	0	.16	.09	1.20	3.97	.86	.18	1.41	0	0	0	0	...
1879-80	0	.33	2.15	6.29	.95	2.00	1.14	2.97	0	0	0	0	...
1880-81	0	0	.86	4.72	1.28	.34	1.75	.50	0	0	0	0	...
1881-82	0	.25	.16	.32	.62	1.70	3.21	1.56	.10	0	0	0	...
1882-83	0	.28	.68	0	1.32	3.17	1.30	.13	2.12	0	0	0	...
1883-84	0	.70	0	2.76	3.00	10.60	10.51	3.48	1.05	2.00	0	0	...
1884-85	0	.42	1.00	4.96	.90	0	T.	1.48	.21	0	0	0	...
1885-86	0	0	7.94	1.17	6.70	T.	3.36	3.39	0	0	0.19	T	...
1886-87	0	.78	.87	.24	.21	8.54	.27	2.52	T.	0	0	0	...
1887-88	.04	.22	.90	1.41	5.09	1.39	3.40	.44	0	0	0	0	...
1888-89	0	.36	3.24	5.40	.09	.63	8.95	.56	.43	0	0	0	...
1889-90	.32	6.17	1.60	14.40	5.40	2.72	.53	.05	.10	0	0	0	...
1890-91	.36	0	.18	1.61	.30	6.32	1.23	.96	.98	0	0	0	...
1891-92	.12	0	0	1.03	.57	2.53	2.65	.21	1.68	0	0	0	...
1892-93	0	.40	1.48	4.40	2.63	3.67	6.93	.56	.08	0	0	0	...
1893-94	0	.61	.05	2.23	.59	.61	.75	.24	.32	0	0	0	...
1894-95	0	.02	0	5.82	7.62	1.11	3.72	.55	.28	0	0	0	...
1895-96	0	.21	.90	.61	2.42	.05	3.32	.29	.15	0	0	0	...
1896-97	0	1.48	.96	2.12	5.39	5.58	2.88	0	0	0	0	0	...
1897-98	0	1.66	0	0	1.42	.57	.86	.10	1.42	0	.17	0	...
1898-99	.10	.25	0	.20	1.29	0	1.45	0	T.	.68	0	0	...
1899-1900	0	1.65	.82	1.04	1.31	0	1.45	.25	1.87	0	0	0	...
1900-1901	T.	.14	6.19	0	4.17	5.20	.15	.72	.62	0	0	0	...
1901-2	T.	1.40	.50	0	1.05	2.72	2.80	.29	0	0	0	0	...
25-year mean	...	...	...	...	...	...	...	...	...	...	...	...	...

Record of precipitation at San Gabriel Electric Company's power house, ... Los Angeles, County.

[Latitude, 34° 09′; longitude, 117° 54′; elevation, 1,000 feet. Authority, San Gabriel E... Company.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	T...
1900-1901	0.19	0	9.76	0	5.23	3.81	0.58	1.35	1.87	0	0	0.08	...
1901-2	0	3.15	.64	0	1.98	3.03	4.69	.36	.23	0.14	0	0	...
2-year mean	...	...	...	...	...	...	...	...	...	...	...	...	...

Record of precipitation at San Gabriel Electric Company's headgate, Los ... County.

[Latitude, 34° 13′; longitude, 117° 52′; elevation, 1,100 feet. Authority, San Gabriel E... Company.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	T...
1900-1901	0.10	0	11.25	0	6.44	5.09	0.48	1.15	2.90	0	0	0.02	...
1901-2	0	4.58	1.08	.18	1.83	3.61	6.24	1.35	.10	.19	0	0	...
2-year mean	...	...	...	...	...	...	...	...	...	...	...	...	...

cord of precipitation at San Gabriel Electric Company's Sierra power house, Los Angeles County.

Latitude, 34° 13′; longitude, 117° 49′; elevation, 2,750 feet. Authority, San Gabriel Electric Company.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
0-1901	.....	.....	.....	.....	10.35	8.15	0.78	0.36	2.78	0.01	0	0	[a]22.43
1-2	0	3.99	0.97	0.24	2.13	3.45	7.53	1.13	.20	.11	.08	0	19.78

[a] Year incomplete.

Record of precipitation at Coulterville, Mariposa County.

[Latitude, 37° 43′; longitude, 120° 12′; elevation, 1,660 feet. Authority, N. C. Ray.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
98-99	0	0	0.76	2.04	4.69	0.46	8.85	0.53	0.34	0.97	0	0	18.64
99-1900	0	4.37	5.70	3.32	2.01	.60	1.47	2.90	1.14	.33	0	0	21.84
00-1901	0.18	3.82	8.27	1.39	4.99	8.04	1.28	.66	3.29	T.	T.	T.	31.92
01-2	1.35	1.92	2.09	1.39	0	0	0	0	0	.09	0	T.	6.82
Year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.81

Record of precipitation at Yosemite, Mariposa County.

[Latitude, 37° 45′; longitude, 119° 35′; elevation, 4,063 feet. Authority, Galen Clark.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
96-97	0 85	1.36	6.19	9.33	6.62	11.53	16.32	0.40	0.62	0.16	.....	.....	[a]53.38

[a] Year incomplete.

Record of precipitation at Camp Wright, Mendocino County.

Latitude, 39° 45′; longitude, 123° 00′; elevation, 1,800 feet. Authority, U. S. War Department.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
64-65	0.03	0.85	6.19	12.20	3.64	4.88	3.57	0.36	0.43	0	0	0	32.15
65-66	.81	.87	16.67	2.05	15.83	4.30	11.80	1.05	.....	.....	.....	.....	[a]53.38
66-67	0	0	5.92	24.67	8.92	7.85	2.38	3.10	.01	0	0	0	52.85
67-68	1.56	3.75	6.38	29.03	8.61	5.89	9.11	3.25	.71	1.58	0	0	69.87
68-69	.05	.25	2.79	6.63	13.57	4.13	3.80	4.51	.55	0	0	0	36.28
69-70	1.42	.84	5.38	8.06	7.03	6.61	2.40	2.02	.39	0	0	0	34.15
70-71	0	0	1.28	1.19	2.66	4.60	7.10	1.07	1.96	0	0	0	19.86
71-72	.50	.31	4.03	16.64	11.52	19.78	5.34	.66	.12	.04	0	0.20	59.14
72-73	0	.36	5.20	7.24	3.55	6.92	2.91	1.13	.04	.30	0.10	0	27.75
73-74	.05	.34	4.98	15.50	12.94	5.46	7.26	3.72	1.16	.26	.01	0	51.68
74-75	0	5.61	12.99	2.27	9.83	1.06	1.76	.59	2.32	0	0	0	36.43
10-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	42.02

[a] Year incomplete.

Record of precipitation at Alturas, Modoc County.

[Latitude, 41° 30′; longitude, 120° 30′; elevation, 4,300 feet. Authority, J. H. Stewart.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1901-2	.....	0.83	0.74	1.21	0.01	.....	.....	.....	.....	.....	.....	.....	2.79

Record of precipitation at Fort Bidwell, Modoc County.

[Latitude, 41° 53′; longitude, 120° 11′; elevation, 4,640 feet. Authority, U. S. War Department.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1866-67	0	1.00	3.50	5.80	12.00	4.80	6.70	1.30	0	0.60	0.10	1.40	37.20
1867-68	2.80	.80	3.10	8.20	3.50	.40	4.00	.60	2.40	4.10	.35	0	30.25
1868-69	.20	.10	.80	.90	2.50	.40	2.36	1.55	.70	.20	.70	0	10.41
1869-70	.45	0	2.37	2.30	12.71	5.40	3.21	1.41	2.87	1.36	.76	.05	33.04
1870-71	0	.03	2.29	9.10	1.23	3.26	3.21	0	.97	.16	.38	.02	20.65
1871-72	.20	.20	.79	3.25	1.16	3.97	1.32	.77	1.82	.06	0	.25	13.79
1872-73	1.18	.46	1.69	1.94	2.22	1.66	.60	2.06	.78	.10	.14	.21	13.04
1873-74	.40	.63	1.14	3.29	1.51	1.08	1.05	1.12	.64	1.06	.05	.27	12.84
1874-75	0	.99	2.74	.13	2.10	.07	2.15	.45	1.30	1.00	0	.05	10.98
1875-76	0	1.80	2.62	1.54	3.57	.32	.80	.53	.98	.43	0	0	12.59
1876-77	0	1.99	4.32	2.05	9.36	3.30	4.10	2.14	4.66	2.10	.10	.35	34.47
1877-78	.10	.80	3.03	.35	.75	4.65	2.35	1.05	.82	.20	.25	.35	16.75
1878-79	.70	.30	.25	.20	3.90	2.63	.95	1.00	1.40	.15	.15	.30	11.53
1879-80	.10	1.34	1.75	6.60	3.10	3.80	3.36	5.60	1.38	.26	.72	.42	28.83
1880-81	.05	.50	.56	6.09	10.00	6.00	1.50	3.02	.84	1.59	.32	.10	30.57
1881-82	.24	3.56	2.87	3.40	3.44	2.82	1.46	1.72	.64	.38	.16	0	20.89
1882-83	.48	2.73	.92	1.77	2.52	.64	.77	1.56	1.30	0	0	0	12.69
1883-84	0	1.18	1.14	1.06	1.14	2.96	.72	.68	.40	4.29	.67	.06	14.30
1884-85	1.40	.73	T.	6.81	2.09	1.82	.04	3.45	1.99	1.05	1.38	.17	24.93
1885-86	.09	.75	8.46	3.74	5.78	2.16	1.48	2.20	1.44	.78	.41	.04	31.33
1886-87	0	1.36	1.06	4.25	3.31	4.85	.97	1.96	1.47	.73	.18	.21	30.35
1887-88	.05	0	.38	2.40	3.28	1.81	3.28	.16	1.50	2.38	.34	.04	25.85
1888-89	.33	.20	2.03	3.28	2.81	.20	7.31	1.08	1.62	.78	0	0	33.04
1889-90	0	3.61	2.20	3.78	7.45	3.97	3.97	.92	1.07	.33	.05	.05	37.40
1890-91	1.60	.10	0	1.00	.50	3.98	3.83	1.39	1.57	2.73	1.55	.19	18.44
1891-92	.13	.19	1.57	2.76	.79	1.20	.69	2.28	1.57	1.46	.15	.02	13.01
1892-93	.91	1.28	3.12	2.64	2.60	2.92	1.60	1.88	1.66	.01	.50	.05	19.27
27-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20.57

Record of precipitation at Jolon, Monterey County.

[Latitude, 36° 00′; longitude, 121° 15′; elevation, 960 feet. Authority, F. T. Tidball.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
2-83	0.50	0.25	2.05	2.75	1.25	0.85	5.05	0.75	2.45	0	0	0	15.90
3-84	0	.60	0	1.00	5.75	7.56	9.02	3.35	.50	0.60	0	0.25	28.63
4-85	0	2.60	.60	4.09	2.31	T.	T.	2.15	0	0	0	0	11.75
5-86	0	.10	13.15	2.42	8.51	.86	2.37	4.01	0	0	0	0	31.42
6-87	0	.35	.48	.61	.57	8.52	.38	1.11	.40	T.	0	0	12.42
7-88	.21	.21	.94	4.42	5.64	.16	4.81	0	.37	.01	T.	0	16.77
8-89	.60	0	5.64	4.48	1.23	1.40	9.65	.59	1.12	0	0	0	24.74
9-90	0	7.38	4.09	11.42	6.58	4.59	2.50	.05	.30	0	0	.03	36.94
0-91	.90	0	.57	2.25	.55	8.75	.99	.94	.02	T.	(.00)	(.00)	14.97
1-92	T.	(.14)	.03	2.99	.84	1.78	2.31	.32	2.25	T.	0	0	10.66
2-93	0	.23	6.40	6.61	3.83	3.29	5.30	1.35	.22	0	0	0	27.23
3-94	0	T.	.15	2.31	1.48	.68	.46	.22	1.35	.52	0.05	.05	7.27
4-95	1.20	.75	.30	8.30	6.16	.32	1.68	.85	.02	0	0	0	19.58
5-96	.03	1.80	.96	.50	8.14	.03	2.61	3.62	.09	0	.10	.03	17.96
6-97	.03	.75	3.20	2.11	4.61	2.50	3.54	0	0	.03	0	.03	16.85
7-98	.15	.43	.12	.46	.85	2.10	.60	.07	.52	T.	0	0	5.30
8-99	.30	.16	.24	.40	4.55	.13	4.31	1.74	.17	T.	0	0	12.00
9-1900	0	2.10	1.50	2.30	3.03	.11	1.00	.68	1.18	0	T.	0	11.90
0-1901	0	2.00	7.53	.53	4.84	6.21	2.58	2.10	.33	0	T.	0	26.12
1-2	.05	1.76	1.69	0	.99	6.49	3.03	1.28	.08	0	0	0	14.77
year mean													18.16

Record of precipitation at Matthews Ranch, near King City, Monterey County.

[Latitude, 36° 15′; longitude, 121° 00′; elevation, 333 feet. Authority, J. L. Matthews.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
01-2			1.37	0.10	0.71	3.74	2.38	0.81					9.11

Record of precipitation at Priests Valley, Monterey County.

Latitude, 36° 12′; longitude, 120° 45′; elevation, 2,250 feet. Authority, A. J. Myers and Mrs. Martin Griffin, Soledad.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total
98 99	0.13	0.17	0.36	0.34	4.01	0	5.30	1.33	0.52	0	0	0	12.16
99-1900	0	3.61	1.82	2.81	2.53	0.16	2.37	1.17	1.23	0	0	0	15.70
00-1901	0	2.50	7.98	.64	6.27	9.51	.80	2.44	1.59	0	0	0	31.13
01 2	0	2.57	2.08	.66	.70	5.42	3.60	1.84	.24	0	0	0	17.11
year mean													19.18

Record of precipitation at Salinas City, Monterey County.

[Latitude, 36° 41′; longitude, 121° 36′; elevation, 45 feet. Authority, Dr. E. K Abbott.

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	T
1871-72											0	0	
1872-73	0.01	0	0.	6.80	3.40	2.40	0.80	0	0	0	0	0	
1873-74	.10	0.10	0.20	4.25	3.42	0	2.15	0.95	0	0	0	0	
1874-75	0	1.83	1.42	0	4.50	.15	.69	0	0	0	0	0	
1875-76	0	0	5.17	1.98	6.16	3.55	4.52	0	0.01	0	0.10	0	
1876-77	.05	1.04	.05	0	2.54	.16	.30	.10	.40	0	0	0	
1877-78	0	.12	1.00	2.39	7.05	8.77	2.57	1.93	0	0	0	0	
1878-79	.05	.60	.20	.35	2.42	2.81	1.85	1.69	.82	0.15	0	0	
1879-80	0	1.05	1.08	2.23	1.65	1.16	1.64	3.90	.46	0	0	0	
1880-81	0	0	.57	5.53	3.32	2.32	1.26	.66	0	.38	0	0	
1881-82	.10	.28	.67	1.24	1.78	2.31	4.86	1.01	.49	.19	0	0	
1882-83	.38	1.43	.65	1.95	.91	.95	2.26	1.28	1.98	0	0	0	
1883-84	.19	1.19	.25	.90	1.71	4.49	5.09	3.05	.72	2.66	0	0.15	
1884-85	.11	1.79	.28	4.45	1.09	.05	.19	1.21	.12	0	0	0	
1885-86	.02	.08	0.60	1.30	5.10	1.47	2.16	3.83	0	0	0	0	
1886-87	0	.62	.82	.72	.75	4.73	.54	1.63	.07	0	0	0	
1887-88	.71	0	.98	2.16	4.15	.53	3.28	0	.89	0	0	0	
1888-89	.56	0	1.64	2.20	.64	1.65	3.31	.95	.68	0	0	0	
1889-90	0	4.20	2.41	8.90	5.99	3.05	1.79	.60	.65	0	0	0	
1890-91	0	.20	.44	2.05	.59	4.40	.43	2.53	.33	0	0	0	
1891-92	.12	.17	.30	4.66	.44	1.57	2.78	.85	.65	0	0	0	
1892-93	.08	.66	4.09	2.13	1.07	2.91	5.14	.91	0	0	0	0	
1893-94	0	.33	.66	1.59	5.17	3.36	.82	.53	1.57	.26	0	0	
1894-95	1.16	.87	.41	5.35	5.10	1.41	2.07	.94	.45	0	0	0	
1895-96	0	.56	.79	.83	5.65	.22	1.68	2.64	.45	0	0	.2	
1896-97	.02	1.01	3.08	2.02	.66	3.34	4.51	.11	.06	.12	0	0	
1897-98	.50	.78	.97	.96	.96	1.66	1.06	.23	1.22	.10	0	0	
1898-99	.17	.88	.34	1.18	2.98	.50	4.11	.75	.14	0	0	0	
1899-1900	0	2.65	2.96	1.80	.84	.77	1.00	1 41	.25	0	0	0	
1900-1901	0	.69	5.65	.71	1.69	5.44	.50	1 48	.35	0	0	0	
1901-2	.38	.50	1.27	.20	1.01	3.50	2.58	.87	.27	0	0	0	
30-year mean													

[a] Year incomplete.

Record of precipitation at San Ardo, Monterey County.

[Latitude, 36° 09′; longitude, 121° 10′; elevation, 452 feet. Authority, Pacific Railway Syst

Year.	Sept	Oct	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	T
1886-87	0	0	0 35	0.17	0.58	5.58	0.17	0.76	0.05	0.26	0	0	
1887-88	0.14	0.37	.32	2.07	3.44	.28	2.91	.11	.27	0	0	0	
1888-89	0	0	3.24	2.31	.83	.80	6.16	.49	.27	0	0	0	
1889-90	0	4.74	2.96	7.16	3.36	3.59	.99	0	.43	0	0	0 04	
1890-91	1.10	0	.11	1.41	.43	3.99	.76	1.04	.03	0	0	0	
1891-92	.14	0	0	1.57	.58	.48	1.37	.08	1.61	0	0	0	
1892-93	0	.15	1.80	3.40	1.55	1.31	3.94	.62	.15	0	0	0	
1893-94	0	0	.21	1.06	1.18	.34	.13	.10	.68	.15	0	0	
1894-95	.65	.25	.02	4.42	3.98	.23	.94	.41	.02	0	0	0	
1895-96	0	1.48	2.86	.30	5.10	0	2.11	2.27	.25	0	0	.2	
1896-97	0	.45	2.73	1.54	.89	1.18	2.19	.05	0	0	0	.02	
1897-98	0	.78	.05	.42	.38	.89	.70	0	.43	0	0	T.	
1898-99	T.	.15	.20	.15	3.24	.03	2.81	.84	T.	T.	0	T.	
1899-1900	0	1.65	.96	1.09	1.68	.15	1.15	.39	.66	T.	T.	0	
1900-1901	T.	.88	4 30	.08	3.89	4.17	.51	.67	1.20	0	0	0	
1901-2	05	.94	1.49	0	.66	4.29	2.20	74	T.	0	0	0	
16-year mean													

Record of precipitation at Boca, Nevada County.

[Latitude, 39° 24'; longitude, 120° 06'; elevation, 5,531 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
9-70	.....	.....	.....	.....	.....	3.85	1.82	0.81	0.55	0.26	0.12	0	a7.41
1-71	0	0.80	0.04	1.10	2.50	2.32	1.60	.45	0	.10	2.00	0	10.91
1-72	0	0	.60	7.30	3.00	.90	10	1.50	10	0	0	0	13.50
2-73	0	0	.20	2.60	1.80	4.10	.10	.10	.75	0	0	0	9.65
3-74	0	0	0	4.30	4.70	2.40	6.20	80	.60	0	60	0	19.60
4-75	.10	2.15	3.70	.60	6.30	0	.65	.60	0	.40	T.	0	14.50
5-76	0	T.	1.56	1.65	8.10	3.60	4.72	.70	.10	0	.22	0.01	20.66
6-77	.01	.25	.02	0	5.22	0	.46	.95	.86	.10	0	0	7.37
7-78	0	0	1.50	.30	3.94	6.74	.86	1.30	0	.13	.08	0	14.85
8-79	.17	.99	1.60	0	5.47	2.92	4.80	2.08	.45	0	0	0	18.48
9-80	0	.20	.98	4.18	0	3.00	2.90	6.95	.75	0	0	0	18.96
0-81	0	0	0	3.74	0	0	.12	0	0	0	0	0	3.86
1-82	.14	.10	1.20	1.00	3.90	3.60	10 20	1.00	0	0	0	0	21.14
2-83	0	.80	.90	.60	1.15	2.20	1 70	.90	1.90	0	0	0	10.05
3-84	.14	2.45	.50	.60	4 60	6.80	5.10	1.90	.30	1 40	0	0	23.29
4-85	T.	.80	0	8.20	1.00	.10	.10	1.50	0	.30	0	0	12.00
5-86	0	0	2.40	2.98	8.35	.85	4.40	1.30	.50	0	.15	0	20.98
6-87	.10	.70	.70	.70	2.40	12.70	0	1.80	T.	.26	.15	T.	19.51
7-88	0	0	.30	3.74	4.18	1.00	2.40	.10	.51	.10	.15	.30	12.92
8-89	.12	0	.95	1.45	4.18	3.63	1.15	.10	3.90	0	0	0	15.48
9-90	.14	1.50	4.55	19.85	14.60	5.40	5.45	1.50	.70	.26	0	0	53 95
0-91	0	.70	0	3.65	1.25	11.80	2.50	1.70	.84	.26	.15	0	22.85
1-92	.60	0	.25	8.30	.70	3.35	1.70	2.70	3.10	.70	0	0	21.40
2-93	0	1.50	8.35	6.95	4.55	8.90	4.00	1.90	1.35	0	0	.05	37.55
3-94	.55	.25	2.42	3.70	5.10	7.55	.75	1.00	.33	T	0	T	21.65
4-95	T.	.61	.50	11.80	8.36	1.20	.45	.70	.90	T	0	T.	24.52
5-96	.97	.11	.01	1.52	7.75	.50	6.30	6.65	3.10	.25	1.15	.18	28.49
6-97	.35	0	2.47	1.80	2.20	6.35	8.35	10	.50	.40	0	.50	23.02
7-98	T	2.10	2.80	2.72	1.55	2.90	2.50	1.30	.85	1.00	0	0	17.72
8-99	01	1.28	1.84	1.58	6.80	1.85	7.95	.85	2.40	.10	0	98	25.64
9-1900	0	4.42	2.59	4.53	1.57	.60	3.52	4.27	1.10	2.67	T.	1.22	26.49
00-1901	.66	3.04	5.73	4.58	7.17	6.76	2.24	2.04	1.86	0	0	.08	34.16
01-2	.40	.80	1.15	3.77	1.30	2.50	2.70	T.	T.	0	.10	0	12.72
3-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.38

a Year incomplete.

Record of precipitation at Bowman's dam, Nevada County.

[Latitude, 39° 27'; longitude, 121° 39'; elevation, 5,400 feet. Authority, H. C. Perkins and W. E. Radford.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Tot.
1871-72	0	0.98	7.88	36.20	12.98	27.08	7.52	4.57	1.09	1.04	0.88	0	
1872-73	0 25	.73	5.43	17.41	5.73	16.17	3.82	3.20	2.65	0	.06	0	
1873-74	0	1.24	4.37	23.47	21.53	9.96	17.73	5.47	3.93	.45	0	0.08	
1874-75	0	4.54	15.35	1.58	16.91	.25	5.18	.83	2.85	2.38	.25	0	
1875-76	0	3.09	23.43	10.77	17.62	11.70	18.01	5.92	.99	.36	1.28	0	
1876-77	.41	10.76	.53	0	14.33	3.18	7.49	3.17	3.33	1.17	0	0	
1877-78	0	1.52	8.28	1.71	17.00	21.21	10.07	2.57	2.06	.10	.09	.13	
1878-79	0	2.83	5.36	1.30	14.50	14.28	20.97	9.57	3.93	.71	.05	.10	
1879-80	0	3 41	9.62	15.00	9.27	8.17	9.51	31.72	8.90	0	0	0	
1880-81	0	0	.65	25.05	27.82	15.08	7.29	4.44	1.22	0	0	0	
1881-82	2.33	6 09	4.25	10.78	11.46	7.47	15.17	7.96	1.16	0	0	0	
1882-83	2.94	11.47	6.51	4.32	5.06	5.28	12.79	5.15	0	0	0	0	
1883-84	2 45	5.03	2.46	5.20	13.50	19.45	18.02	12.44	2.01	3.53	0	0	
1884-85	1.08	3.04	0	46.57	4.49	3.74	.80	6.41	1.57	2.64	0	0	
1885-86	1.26	0	24.96	8.66	17.84	2.99	7.24	13.22	3.20	0	0	0	
1886-87	0	2.25	1.76	6.95	7.46	21.60	2.27	5.81	1.93	.76	0	0	
1887-88	0	0	1.25	8.97									
1894-95						8.77	9.65		9.15	0	T.	.2	
1895-96	10.12	.45	2.81	11.20	29.85	1.92	14.95	18.45	8.98	.11	.09	1.0	
1896-97	2.05	2.83	19 40	10.31	4.88	18.31	18.91	2.85	.92	4.04	0	T.	
1897-98	.61	4.74	5.35	5.31	3.01	12.23	2.63	2.10	3.95	2.12	0	0	
1898-99	.55	2.64	7.51	3.22	14.11	2.54	26.31	1.73	4.80	1.04	0	1.15	
1899-1900	0	16.27	12.53	15.72	9.60	4.44	10.77	6.62	2.67	.40	.02	0	
1900-1901	1.35	12.98	11.47	8.15	14.30	18.79	4.67	5.99	1.73	T.	T.	.05	
1901-2	4 12	4.28	7.54	8.01	2.40	21.08	9.26	5.96	2.76	.46	.09	T.	
23-year mean													

[a] Year incomplete.

Record of precipitation at Grass Valley, Nevada County.

atitude, 39° 13′; longitude, 121° 4′; elevation, 2,090 feet. Authority, Mr. Lontzenhuser and B. F. Berriman.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
72–73	0	0	0	13.13	4.01	12.52	1.39	2.32	2.56	0	0	0	35.93
73–74	0	0.83	2.99	19.01	13.71	6.98	11.71	3.76	1.05	0.10	0	0	60.09
74–75	0	2.95	15.91	1.08	15.56	1.39	4.14	.29	1.18	2.28	0	0	44.78
75–76	0	.97	16.99	7.44	12.01	10.75	12.47	2.80	1.23	0	.65	0	65.31
76–77	0.06	8.72	.62	0	10.18	2.44	4.79	1.14	1.40	.74	0	0	30.09
77–78	0	1.21	3.78	1.74	15.74	17.76	10.18	2.78	.59	0	0	0	53.78
78–79	.68	2.09	2.54	.75	10.72	11.51	18.07	7.08	3.08	.80	0	0.08	56.90
79–80	0	2.79	6.54	8.86	6.40	4.83	4.07	2.33	6.23	.09	0	0	42.14
80–81	0	.04	.30	22.69	19.20	8.50	3.33	1.85	.05	1.50	0	0	57.46
81–82	1.25	3.71	3.52	8.21	6.08	6.30	7.96	5.27	1.18	0	0	0	43.43
82–83	1.88	7.88	4.78	2.83	3.05	2.97	9.25	2.38	5.77	0	0	0	40.79
83–84	1.44	3.03	1.48	2.31	7.80	10.27	13.98	10.98	1.00	2.30	0	0	54.59
84–85	.98	3.30	.05	28.39	3.65	1.76	.83	3.17	.16	.90	0	0	43.19
85–86	2.65	0	19.27	6.36	12.40	1.43	4.83	11.38	1.09	0	0	0	59.41
86–87	0	1.66	.67	5.46	3.38	15.72	1.69	6.54	.64	.52	0	0	36.28
87–88	.26	0	1.38	6.85	11.81	2.59	5.22	.50	.38	2.26	.08	0	31.33
88–89	.55	0	4.29	8.70	.64	1.08	12.95	3.87	7.21	.40	0	0	39.69
89–90	0	12.49	8.76	21.08	18.64	10.02	13.69	3.52	3.10	.02	0	0	91.32
90–91	1.95	0	0	5.51	1.54	13.70	6.22	2.98	2.06	1.27	.90	0	36.13
91–92	.21	1.00	1.76	10.26	4.70	7.15	6.61	6.37	6.49	0	0	0	44.55
92–93	.23	2.72	13.44	11.22	7.31	6.83	12.40	5.80	1.30	0	T.	0	61.25
93–94	1.64	1.49	8.77	5.55	11.24	11.72	2.96	1.67	3.46	2.05	T.	.03	50.58
94–95	1.01	4.91	1.38	16.55	22.26	6.18	5.01	3.38	3.46	0	.25	.24	64.63
95–96	3.87	.02	1.17	7.27	20.34	.93	6.94	12.47	4.87	.13	.02	.13	58.16
96–97	1.53	1.72	13.65	5.78	3.65	14.40	8.47	2.25	.10	.62	.04	.03	52.24
97–98	.51	3.07	4.56	3.97	1.44	8.36	.52	(.90)	2.53	1.27	T.	T.	27.13
98–99	.61	2.08	4.31	2.73	10.76	.47	19.60	1.70	2.72	.83	0	.42	46.23
99–1900	0	10.33	11.58	11.35	6.90	2.54	7.40	3.92	1.31	.65	.04	.03	56.05
8-year mean													49.41

Record of precipitation at Malakoff mine, Nevada County.

[Latitude, 39° 22′; longitude, 120° 50′; elevation, 3,200 feet. Authority, R. D. Wheeler.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1886–87	0	2.39	0.80	5.32	5.06	18.12	2.27	7.52	0.89	0.49	0	0	42.86
1887–88	0.64	0	1.68	8.26	12.14	2.67	.....	.....	.....	.....	.....	.....	[a]25.39
1894–95	.....	.....	.....	.....	24.40	7.28	7.01	5.18	6.03	0	0.14	0.41	[a]50.45
1895–96	6.22	.56	2.27	7.36	24.11	1.36	10.20	17.78	6.61	T.	.06	.15	76.68
1896–97	1.90	2.33	17.42	7.02	.....	.....	.....	.....	.....	.....	.....	.....	[a]28.67
2-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	59.77

[a] Year incomplete.

Record of precipitation at Nevada City, Nevada County.

[Latitude, 39° 16'; longitude, 121° 2'; elevation, 2,500 feet. Authority, J. S. Brown

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	T...
1863-64	0	0	1.00	3.50	0.90	0.50	5.38	3.25	2.75	0	0	0 5	
1864-65	0	0	17.05	17.42	9.71	4.38	2.09	1.75	1.31	0	0	0	
1865-66	0.59	2.03	14.29	1.95	15.47	5.60	14.24	.59	4.50	0	0	0	
1866-67	0	0	9.61	32.70	14.21	10.00	6.23	6.88	1.93	0	0	0	
1867-68	1.91	3.63	16.11	41.95	11.01	6.36	23.30	7.22	1.50	2.27	0	0	
1868-69	.34	.43	1.49	10.62	16.85	12.62	6.96	5.72	1.62	.04	0	0	
1869-70	.15	.50	4.67	6.29	9.28	14.48	7.58	4.70	.65	.36	0.03	0	
1870-71	0	3.82	4.32	5.32	11.08	6.23	5.41	5.55	3.26	.33	0	0	
1871-72	0	.79	5.00	27.31	18.16	16.67	5.28	3.76	.17	1.08	0	0	
1872-73	0	.55	4.05	12.25	2.82	12.40	1.96	2.47	2.20	0	0	0	
1873-74	0	.67	1.35	24.27	11.16	7.32	12.20	4.51	1.32	.11	0	0	
1874-75	0	3.06	15.08	.90	16.57	2.11	3.97	.27	1.56	2.43	0	0	
1875-76	0	1.75	16.56	5.90	12.47	12.41	13.88	2.17	1.53	0	0	0	
1876-77	.41	9.85	1.04	0	10.26	2.45	4.18	1.43	1.97	.72	.71	0	
1877-78	0	1.35	4.31	2.65	17.62	16.61	10.05	2.80	1.05	0	0		
1878-79	.69	2.32	2.88	.96	11.62	10.97	19.28	5.90	3.83	.43	0	6	
1879-80	0	3.15	5.50	8.76	6.67	5.48	5.09	22.54	5.58	.15	0	0	
1880-81	0	.06	.28	24.78	18.88	6.26	4.44	1.70	0	1.47	0	0	
1881-82	1.38	3.03	2.53	9.14	7.29	5.42	9.21	4.39	.52	0	0		
1882-83	2.22	7.65	5.34	3.87	2.39	3.06	14.27	2.98	6.92	0	0	0	
1883-84	1.28	3.60	1.62	2.84	9.06	12.01	14.70	12.07	1.67	2.47	.06		
1884-85	1.87	3.61	0	27.92	4.39	1.09	.53	3.23	.21	1.36	0		
1885-86	1.62	0	21.55	6.77	13.66	1.54	6.92	12.49	1.23	0	0	.05	
1886-87					3.51	12.64	4.80	7.24	.70	.37	0	0	
1887-88	.71	0	1.70	7.53	11.32	3.52	7.14	.68	.42	2.40	0	0	
1888-89	.06	0	4.09	8.44	T	2.59	14.68	5.20	7.62	.58	.06	0	
1889-90	0	13.05	8.55	24.50	24.05	10.07	13.40	3.11	3.35	.01	0	0	
1890-91	2.04	.04	.04	6.38	2.18	18.66	3.64	2.93	1.92	.73	0		
1891-92	.04	.90	1.42	9.56	6.48	6.04	7.27	7.17	5.80	.20	0	T.	
1892-93	.26	.95	13.87	14.19	8.02	8.29	12.75	6.22	1.33	0	T.		
1893-94	1.71	1.25	7.78	5.23	11.71	10.85	3.26	2.17	3.54	1.85	0	T	
1894-95	1.21	4.83	1.38	20.61	22.87	5.53	5.12	3.82	3.42	0	.15		
1895-96	3.36	0	1.87	6.14	19.61	.99	7.39	13.63	4.88	T.	.05		
1896-97	1.55	2.18	12.63	6.46	4.38	13.63	9.13	2.08	.22	.82	0	T	
1897-98	.60	3.36	4.38	3.17	1.92	9.91	.87	.95	2.73	1.27	0	T	
1898-99	.37	1.96	3.49	2.27	9.12	.49	15.88	1.52	2.61	.91	0		
1899-1900	0	10.24	10.85	10.27	7.81	2.36	7.51	4.83	1.90	.03	T.		
1900-1901	.55	5.52	9.22	4.00	11.52	13.12	2.35	5.59	1.29	0	T.		
1901-2	3.36	4.16	5.45	5.35	1.91	18.28	5.02	4.66	1.47	.24	0		
38-year mean													

[a] Year incomplete.

NOTE.—Record from January, 1887, to February, 1892, inclusive, from J. F. Colley.

Record of precipitation at North Bloomfield, Nevada County.

atitude, 39° 22'; longitude, 120° 54'; elevation, 3,160 feet. Authority, H. C. Perkins and W. H. Radford.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
0-71	0	1.61	3.24	4.31	7.54	5.94	5.03	4.36	3.36	0.12	0	0	35.51
1-72	0	.83	6.20	25.19	12.71	18.22	5.73	3.84	1.39	.41	0	0	74.52
2-73	0.16	.53	4.47	11.77	4.16	11.09	2.50	2.40	1.57	0	0.10	0	38.75
3-74	0	.67	3.37	19.00	15.17	7.08	11.16	4.04	1.78	.25	0	0.02	62.54
4-75	.06	4.88	13.52	1.21	.15	.88	3.56	.30	2.68	.63	0	0	27.87
5-76	0	2.09	15.53	7.64	10.98	10.20	13.02	4.03	1.06	.01	1.76	.01	66.33
6-77	.31	10.46	.85	0	9.98	2.80	4.92	3.07	2.66	.91	0	0	36.05
7-78	0	1.10	4.22	1.96	15.72	16.97	9.23	2.44	.95	0	0	0	52.59
8-79	0	3.34	3.72	1.18	10.00	9.49	16.62	6.69	3.84	.64	0	.24	55.76
9-80	0	3.03	6.43	13.57	5.96	5.66	5.45	23.31	5.63	0	0	0	69.04
0-81	0	0	.41	21.10	19.46	12.13	4.92	2.59	1.33	1.57	0	0	63.51
1-82	1.75	3.86	4.05	8.73	8.02	6.77	10.02	5.39	1.82	0	0	0	50.41
2-83	2.74	6.86	5.72	3.59	3.09	3.94	10.45	3.39	0	0	0	0	40.38
3-84	1.79	3.66	1.48	2.84	9.21	10.02	15.65	10.31	2.66	4.03	0	0	61.65
4-85	1.98	3.43	0	37.21	3.65	1.91	.79	3.62	.71	2.14	0	0	55.44
5-86	2.55	0	20.23	7.98	13.49	1.78	2.18	12.26	1.15	0	0	0	61.62
6-97	1.90	2.33	17.42	7.02	5.06	16.57	11.16	3.70	.20	1.45	0	.11	66.92
7-98	.57	5.05	6.12	5.41	2.28	13.03	.79	1.18	4.47	1.70	T	T	40.60
8-99	.58	2.87	5.66	4.10	10.88	1.01	18.24	1.98	3.91	.65	0	.67	50.55
9-1900	0	14.52	13.33	13.09	9.32	5.20	9.64	6.82	2.44	T	.01	0	74.37
0-1901	.95	8.32	10.99	4.95	7.73	13.46	2.97	6.27	1.73	0	T	T.	57.37
01-2	4.51	3.98	4.68	5.87	1.60	18.04	6.40	5.29	1.70	.19	.09	.04	52.39
-year mean													54.28

Record of precipitation at Truckee, Nevada County.

[Latitude, 39° 19'; longitude, 120° 01'; elevation, 5,820 feet. Authority, Pacific Railway Sys

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug
1869-70	.....	.....	.....	.....	.....	6.18	4.35	0.12	2.40	0.80	1.30	.....
1870-71	0	0	0.51	1.67	4.80	4.23	3.18	2.00	.28	.35	0	0
1871-72	0.20	0.02	5.35	16.23	3.42	10.49	3.63	4.11	.60	.30	0	0
1872-73	0	.40	.60	3.74	3.78	9.55	1.69	1.36	.55	0	T.	0
1873-74	0	.11	.42	8.70	9.54	6.15	9.35	2.61	.68	.11	.56	0.0
1874-75	.04	2.44	3.54	.60	8.50	.20	1.20	.90	0	1.81	.40	.0
1875-76	T.	.62	8.94	4.90	9.85	5.50	6.95	1.83	.84	.01	.05	.0
1876-77	.08	3.64	.07	.05	9.45	.39	1.84	1.08	1.12	.36	0	0
1877-78	.04	0	1.66	.24	5.97	11.80	2.07	.80	1.17	.10	0	.2
1878-79	.23	.75	2.14	.50	7.70	2.68	5.25	1.55	.45	0	0	0
1879-80	.07	1.40	3.78	4.98	2.95	4.65	4.65	12.74	2.50	0	.16	0
1880-81	0	0	.45	9.51	5.71	2.13	1.86	.49	.40	1.26	.18	0
1881-82	.25	2.50	2.70	3.80	6.40	4.95	12.05	1.89	.85	.98	.60	0
1882-83	0	.85	1.04	.80	1.55	3.05	1.65	2.19	1.13	0	.53	0
1883-84	.28	2.46	2.50	1.62	6.65	11.20	5.38	3.90	.14	1.62	0	0
1884-85	.78	1.50	0	13.14	1.80	.54	.56	2.04	.08	0	0	.2
1885-86	.47	0	6.95	2.22	7.08	.50	2.90	1.78	.60	.56	.80	0
1886-87	T.	.85	1.10	2.39	8.43	12.25	.36	2.00	2.04	.37	.40	T.
1887-88	0	0	.30	4.80	2.35	0	0	T.	.70	.80	.72	0
1888-89	.28	0	2.38	1.58	.80	1.40	2.51	1.01	4.51	0	0	0
1889-90	0	3.13	3.29	2.51	16.20	8.90	7.29	.45	1.44	0	0	.2
1890-91	.80	.45	0	3.70	1.22	8.36	3.92	2.17	2.90	.46	0	0
1891-92	.98	.05	.45	6.34	2.65	2.80	3.00	2.96	4.20	.95	0	0
1892-93	29	.37	5.73	8.15	5.44	8.02	5.18	3.73	1.79	0	0	0
1893-94	1.22	.35	3.96	2.82	8.06	10.95	2.65	2.15	1.05	T.	0	0
1894-95	.13	1.12	.60	13.95	11.13	1.92	1.72	.50	2.40	0	0	0
1895-96	1.32	.34	.50	2.96	7.07	.40	4.67	9.36	.54	0	.15	.3
1896-97	.32	.40	3.86	2.50	2.35	7.97	2.84	.30	T.	.18	0	0
1897-98	T.	.55	3.20	3.15	1.05	3.65	2.05	.25	.30	0	0	0
1898-99	.40	.06	2.95	1.50	7.80	2.70	9.50	1.10	.75	0	0	.2
1899-1900	0	6.49	2.80	1.80	2.63	.80	4.20	1.90	.80	1.01	0	0
1900-1901	0	1.02	2.50	2.70	5.00	7.97	2.50	1.80	.70	0	0	0
1901-2	.50	2.78	3.63	1.55	1.10	3.30	5.60	1.28	.55	0	.45	1.0
32-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

[a] Year incomplete.

NOTE.—During July, 1902, there was also 3 feet of snow at Truckee.

Record of precipitation at Alta, Placer County.

[Latitude, 39° 13'; longitude, 120° 49'; elevation, 3,612 feet. Authority, Pacific Railway Sys

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug
1869-70	.....	.....	.....	.....	.....	13.75	6.56	3.73	1.32	0.66	.....	.....
1870-71	0	0	2.75	3.94	5.21	5.45	7.00	3.50	1.50	0	0	0
1871-72	0	0	T.	6.50	11.25	13.85	.45	.38	0	0	0	0
1872-73	0	0.25	.19	6.50	1.65	10.00	.95	3.03	0	0	0	0
1873-74	0.40	0	.90	15.59	12.66	7.17	3.76	5.75	1.27	0	0	0
1874-75	0	3.92	12.86	.09	13.17	.01	3.40	.40	.12	2.00	0	0
1875-76	0	.02	18.52	8 30	7.70	4.72	9.08	1.07	1.80	0	0.02	0
1876-77	0	7.00	.70	0	10.00	2.35	6.10	2.60	2.61	.80	0	0
1877-78	0	1.70	3.90	1.00	9.10	14.80	11.65	2.50	.33	0	0	0
1878-79	.60	2.96	4.18	1.00	12.80	13.10	24.30	7.73	2.45	0	0	0
1879-80	0	1.50	9.53	10.02	2.70	4.90	3.10	11.60	2.90	0	0	0
1880-81	0	0	1.00	13.80	21.00	11.80	3.50	.50	0	0	0	0
1881-82	1.12	4.50	5.60	13.60	5.93	6.40	15.40	3.20	1.15	.80	0	0
1882-83	2.70	7.65	5.64	2.31	4.08	1.60	9.06	3.43	6.07	0	0	0
1883-84	.60	1.60	2.05	3.10	3.50	8.60	7.00	5.20	.50	3.00	0	0
1884-85	.12	1.00	0	14.08	1.50	.60	.10	2.48	0	1.00	[b]	...
14-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

[a] Year incomplete.

[b] Alta ceased reporting after June, 1885.

Record of precipitation at Auburn, Placer County.

titude, 38° 53′; longitude, 121° 05′; elevation, 1,363 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
-70						7.31	3.92	2.63	0.45	0.81	0	0	[a]15.12
-71	0	0	0	0.46	7.21	2.36	1.85	3.57	2.06	0	0	0	17.51
-72	0	0.54	2.80	13.55	6.80	9.35	3.59	2.50	.65	.22	0	0	40.00
-73	0	.38	3.13	8.43	3.74	7.44	.53	1.22	.32	0	0	0	25.19
-74	0	.34	1.25	11.97	7.46	4.14	6.26	2.56	.57	0	0	0	34.55
-75	0	1.57	9.64	.82	10.00	.44	2.73	.10	.61	1.82	0	0	27.73
-76	0	.85	11.39	6.05	7.56	5.62	10.10	1.97	.61	0	0.41	0.21	44.77
-77	0	4.52	.65	0	6.94	1.47	2.14	.72	1.53	.27	0	0	18.24
-78	0	.99	2.46	1.55	10.61	10.19	7.60	1.75	.98	0	0	0	36.13
-79	0.50	.89	1.53	.91	6.34	7.16	8.78	5.94	2.43	.46	0	0	34.94
-80	0	2.33	3.82	7.88	3.13	4.90	2.62	13.02	3.85	0	0	0	41.55
-81	0	0	.25	13.91	9.61	8.20	2.43	1.38	0	1.40	0	0	37.18
-82	.92	2.72	3.01	5.87	4.60	4.99	6.05	4.63	.53	.28	0	0	33.60
-83	.84	5.19	4.08	1.65	2.86	1.06	5.19	.70	4.07	0	0	0	25.64
-84	1.70	2.51	1.00	2.52	5.33	7.63	10.17	8.02	.85	1.23	0	0	40.96
-85	.56	2.25	0	16.37	1.74	1.27	.57	2.10	0	.70	0	0	25.56
-86	.64	0	15.24	4.05	8.25	0	4.10	9.38	.65	0	0	0	42.31
-87	0	.89	1.26	4.88	2.04	12.38	1.50	4.34	.30	0	0	T.	27.59
-88	1.09	0	1.22	4.90	7.07	1.40	3.25	.80	.40	1.55	0	(T.)	21.68
-89	.30	0	4.20	5.82	.33	.52	9.57	1.36	4.65	0	0	0	26.75
-90	0	5.75	4.85	11.94	8.97	3.96	8.08	2.83	2.30	0	0	0	48.68
-91	2.63	.14	0	5.13	.88	6.80	5.40	2.23	.88	.69	0	0	24.78
-92	0	1.33	.95	7.36	4.00	4.91	5.96	3.11	4.55	0	0	0	32.17
-93	.15	1.76	6.13	8.99	5.33	4.74	9.20	3.71	.78	0	0	0	40.79
-94	.70	1.11	5.32	3.88	6.96	9.89	1.95	1.35	2.77	1.38	T.	T.	35.31
-95	.67	3.87	7.09	13.56	12.99	4.14	3.09	3.38	1.88	0	T.	.13	50.80
-96	2.04	.12	1.04	3.39	11.88	.49	6.21	7.66	2.42	.43	.14	.25	36.07
-97					2.78	11.40	8.05	1.51	.28	.17	0	T.	[a]24.19
-98	.20	2.83	2.22	3.50	1.13	6.44	.32	.49	2.26	.97	T.	0	20.36
-99	.26	1.75	3.59	2.75	4.78	.17	13.25	.51	1.28	1.43	0	.03	29.80
-1900	0	5.94	9.00	5.47	5.47	2.11	3.69	3.42	2.19	T.	0	0	37.29
-1901	.45	4.50	6.38	2.01	7.82	8.84	1.25	4.83	.98	0	T.	0	36.96
-02	2.39	5.71	4.86	3.95	1.70	12.72	4.80	3.10	.80	.50	T.	.02	40.55
Year mean													33.40

[a] Year incomplete.

Record of precipitation at Cisco, Placer County.

[Latitude, 39° 19′; longitude, 120° 33′; elevation, 5,939 feet. Authority, Pacific Railway Syst

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	
1869-70						13.46	3.70	0.65	0.40			0	
1870-71	0	1.20	2.80	4.40	6.40	8.40	2.40	3.05	4.95	0.85	0	0	
1871-72	0.40	.20	6.20	24.89	6.50	12.55	3.98	6.05	1.14	1.03	0.53	T.	
1872-73	0	.60	2.65	9.51	5.60	14.00	1.60	1.60	1.50	0	0	0	
1873-74	0	.55	1.35	14.40	7.70	7.00	14.00	4.10	3.10	0	0	0	
1874-75	.50	2.70	7.07	.50	8.40	.45	4.80	.90	.82	2.05	0	0	
1875-76	0	1.75	8.55	5.30	18.50	22.20	17.20	.70	1.20	T.	0	0	
1876-77	0	2.48	4.20	0	7.20	.30	.53	2.87	3.71	.80	0	0	
1877-78	0	.60	4.52	1.30	9.60	11.85	2.00	2.00	4.00	0	0	0	
1878-79	.20	1.45	1.85	1.25	9.30	10.34	16.42	5.50	2.90	.30	.03	0.04	
1879-80	0	2.10	8.17	8.92	4.80	7.10	7.60	11.90	3.90	.08	0	0	
1880-81	.01	.82	.62	16.33	33.46	12.91	6.10	4.81	0	3.30	0	0	
1881-82	2.16	2.93	3.60	8.76	11.71	8.50	25.20	5.60	.91	.48	0	0	
1882-83	.83	8.28	3.75	2.88	.90	4.85	9.25	3.50	6.96	0	0	0	
1883-84	0	1.50	2.20	2.70	8.40	12.00	14.65	10.10	0	3.45	0	0	
1884-85	1.40	2.32	0	25.05	2.90	1.28	2.20	3.95	.30	.95	0	0	
1885-86	.50	0	17.05	4.87	14.75	2.40	7.40	7.50	1.45	0	0	0	
1886-87	0	1.45	1.05	6.10	4.90	22.85	.80	3.95	.40	0	T.	0	
1887-88	.15	0	1.60	8.80	9.75	2.72	6.10	2.20	1.50	1.20	0	0	
1888-89	.68	.15	5.38	9.88	1.40	9.97	2.70	1.65	8.10	.47	0	0	
1889-90	0	11.72	9.54	25.57	22.90	14.90	8.70	1.50	2.50	.30	0	0	
1890-91	3.11	.55	0	7.90	2.20	11.88	6.45	3.70	2.25	3.75	.30	0	
1891-92	.21	1.00	1.76	2.83	5.10	7.61	8.55	6.30	8.30	1.40	0	0	
1892-93	.30	.95	12.60	11.20	3.20	8.50	7.78	0	1.60	T.	0	0	
1893-94	0	0	5.38	8.80	16.45	18.65	5.30	3.55	2.60	0	0	0	
1894-95	.10	.90	1.50	21.60									
1895-96													
1896-97					3.90	10.20	15.20	7.00					
1897-98	.49	2.48	14.00	.50	3.80	5.60	1.30	9.00	3.40	1.10	0	0	
1898-99	.83	2.10	4.80	1.10	10.70	2.60	19.56	1.30	2.10	2.10	0	0	
1899-1900	0	12.83	13.47	12.14	8.40	6.43	9.56	4.85	1.53	.60	.15	0	
1900-1901	.33	7.57	10.43	7.50	10.95	22.45	4.70	4.40	3.25	0	0	0	
1901-02	2.41	3.27	5.38	8.80	1.54	14.17	5.40	1.80	.90	.40	T.	T.	
29-year mean													

[a] Year incomplete.

Record of precipitation at Colfax, Placer County.

itude, 39° 06′; longitude, 120° 57′; elevation, 2,421 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
-70	------	------	------	------	------	5.55	5.41	3.19	0.25	------	0	0	[a]14.40
-71	0	1.21	2.58	3.94	7.24	4.85	4.30	4.03	2.56	0.13	0	0	30.83
-72	0	0	4.25	9.80	10.02	13.68	4.69	3.40	.61	.40	0	T.	46.85
-73	T.	0	3.99	10.48	2.90	11.12	1.24	1.81	2.04	0	T.	0	33.58
-74	0	0	2.27	18.84	10.93	6.62	10.12	3.53	1.31	0	0	0	53.62
-75	0	3.36	13.89	1.12	12.32	.19	3.23	.20	1.90	0	0	0	36.21
-76	0	.95	14.84	7.10	10.40	7.20	14.39	3.23	1.42	T.	0	0	59.53
-77	0	7.98	.62	0	9.29	1.76	4.36	1.36	1.67	.57	0	T.	27.61
-78	0	.95	3.38	1.76	13.10	12.21	9.22	1.79	.42	T.	0	0	42.83
-79	0.56	0	2.08	.85	8.73	8.87	14.62	6.57	2.91	.27	0	0	45.46
-80	0	2.94	4.68	9.16	4.53	6.60	2.85	21.09	4.29	0	0	0	56.14
-81	0	T.	0	16.47	15.59	9.30	3.83	1.53	T.	1.31	0	0	48.03
-82	1.63	1.88	3.40	8.01	9.09	7.11	6.97	3.98	1.13	.13	0	0	42.83
-83	.40	2.96	4.03	3.60	1.68	3.23	7.98	2.93	5.92	0	0	0	32.73
-84	1.08	2.97	1.34	2.32	7.57	9.73	12.27	10.94	1.38	3.01	0	0	52.61
-85	.80	2.55	T.	23.60	2.85	1.66	.68	2.29	0	1.18	0	0	35.61
-86	.62	0	15.48	6.77	12.17	.34	3.69	10.86	1.08	0	0	0	51.01
-87	0	1.96	.46	6.12	2.99	9.24	1.51	4.92	.72	0	0	0	27.92
-88	.68	.84	1.61	6.00	13.28	2.18	2.80	.95	.17	2.60	0	0	31.20
-89	.25	.10	3.28	9.57	.50	.90	13.90	3.00	9.14	.25	0	0	40.89
-90	0	9.95	9.60	21.85	17.90	8.00	14.70	3.95	3.85	0	0	0	89.80
-91	2.75	T.	0	4.54	1.95	14.60	9.60	2.45	1.70	2.60	0.90	0	40.89
-92	0	.40	1.06	11.04	4.85	7.55	7.45	5.73	6.14	.60	0	0	44.82
-93	.53	2.20	1.55	16.95	7.62	5.68	12.80	4.22	1.30	.0	0	0	52.85
-94	.85	1.23	9.32	5.08	13.43	9.76	3.60	4.48	3.45	2.45	0	0.03	54.08
-95	1.00	5.75	0	24.17	20.57	5.55	4.76	0	4.80	0	0	.28	66 88
-96	2.29	0	1.77	8.85	23.23	.93	6.36	16.15	5.39	0	0	.10	65.07
-97	1.64	1.62	14.39	5.58	4.15	15.86	7.46	0	0	85	0	0	51.55
-98	T.	3.86	3.28	5.80	1.80	9.61	1.89	1.38	2.98	1.50	0	0	32.10
-99	.36	1.42	4.46	3.01	9.29	.87	20.73	1 16	2.41	1.72	0	.30	45.73
-1900	0	9.63	13.06	12.83	6.41	4.38	7.79	5.74	3.12	.10	0	0	63.06
-1901	1.00	7.33	12.27	3.96	13.91	15.75	2.85	6.55	1.91	0	0	0	65.33
-02	2.95	4.45	4.82	5.45	.98	18.14	7.11	4.84	.90	.70	0	.02	50.36
ear mean	------	------	------	------	------	------	------	------	------	------	------	------	47.44

[a] Year incomplete.

Record of precipitation at Emigrant Gap, Placer County.

[Latitude, 39° 17′; longitude, 120° 40′; elevation, 5,230 feet. Authority, Pacific Railway ...]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb	Mar.	Apr.	May.	June.	July.	Aug.	...
1869-70	.....	.....	.....	.....	.....	.....	6.39	3.16	0.46	0.04	0	0	...
1870-71	0	1.63	3.00	6.30	5.75	7.15	2.75	2.80	3.34	.41	0	0	...
1871-72	.....	.....	.....	.....	.....	.....	14.58	6.08	4.44	.27	0	0	0	...
1872-73	0	.50	.20	15.65	6.30	18.50	2.70	1.58	3.34	0	0.01	0	...
1873-74	0	1.25	2.70	17.30	10.02	10.42	22.12	.50	.63	.63	0	0	...
1874-75	0	2.00	1.00	.40	5.85	.20	2.90	1.00	2.50	1.50	0	0	...
1875-76	0	0	9.10	3.90	14.80	5.70	7.30	2.70	1.50	.80	.30	0	...
1876-77	0	1.75	.60	0	4.30	.05	.50	.50	1.20	.83	T.	0	...
1877-78	0	.32	5.44	1.62	15.72	16.87	7.17	3.87	.53	0	0	0	...
1878-79	.65	2.25	3.04	.75	15.43	13.21	21.69	7.76	2.81	.34	0	0	...
1879-80	0	3.30	5.11	12.33	10.10	9.88	9.75	21.76	3.42	.06	0	0	...
1880-81	0	0	.30	15.38	25.69	5.42	5.49	4.63	.37	2.54	0	0	...
1881-82	1.70	6.68	2.90	5.64	10.03	9.46	16.60	2.60	1.55	.40	0	0	...
1882-83	.60	7.95	2.15	3.31	3.22	4.00	10.06	3.30	4.90	0	0	0	...
1883-84	1.25	3.66	1.20	3.15	8.22	10.20	15.18	10.84	2.10	2.77	0	0	...
1884-85	.91	1.98	0	31.20	2.68	2.15	.40	3.89	.20	1.83	0	0	...
1885-86	.53	0	18.69	7.38	18.28	1.97	6.90	11.90	2.73	T.	0	0	...
1886-87	0	2.98	.40	8.00	4.12	18.80	2.03	6.17	1.02	1.14	0	0	...
1887-88	.05	3.00	1.50	7.70	17.05	3.92	5.42	3.30	2.23	3.04	62	1	...
1888-89	.10	0	1.77	7.39	1.10	1.10	5.69	2.29	8.61	.38	0		...
1889-90	0	11.81	11.41	20.85	16.90	9.80	13.15	1.72	3.37	0	0	0	...
1890-91	.32	.65	0	6.20	1.70	7.88	4.55	3.15	2.70	2.40	0	0	...
1891-92	0	.20	2.40	12.90	5.42	7.46	5.70	3.00	5.60	.70	0	0	...
1892-93	.10	1.70	15.02	19.97	5.50	6.38	10.05	5.71	.69	0	0	0	...
1893-94	1.20	2.00	5.95	9.19	10.10	15.50	18.00	2.62	1.60	2.29	0	0	...
1894-95	0	2.41	.90	9.19	17.90	1.40	.50	1.60	1.20	0	0	0	...
1895-96	.31	2.41	1.90	4.00	17.40	7.88	8.00	11.50	1.20	.30	T	0	...
1896-97	.....	.....	.....	.....	2.70	2.96	12.80	1.40	T.	.....	.....	.....	...
1897-98	.....	.....	5.56	.....	.....	.....	1.20	1.10	.....	.....	.....	.....	...
25-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...

[a] Year incomplete.

Record of precipitation at Iowa Hill (Strawberry Flat), Placer County.

[Latitude, 39° 07′; longitude, 120° 49′; elevation, 2,825 feet. Authority, C. F. Macy.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
-79					12.50	12.50	18.25	7.87	3.25	0.25	0	0	[a]54.62
-80	0	3.50	3.63	13.35	5.00	6.10	7.88	18.87	6.25	0	0	0	64.58
-81	0	.75	.75	20.80	20.75	10.50	4.62	3.15	.13	2.12	0	0	63.57
-82	2.50	4.25	3.90	10.56	8.92	6.80	10.43	7.59	1.55	.73	0	0	57.23
-83	.35	8.50	6.63	2.69	4.37	4.24	10.63	3.67	7.22	0	0	0	48.30
-84	.75	4.54	2.02	3.75	8.05	11.26	16.50	13.22	1.60	2.52	0	0	64.21
-85	1.60	2.43	0	24.22	3.03	1.48	.68	2.93	.05	1.60	0	0	38.02
-86	1.20	0	15.82	6.14	10.89	.68	6.46	12.19	1.87	0	0	T.	55.25
-87	0	2.28	.80	5.75	3.61	15.61	2.23	6.55	.78	0	0	0.05	37.66
-88	.48	0	.95	6.52	11.73	2.41	4.59	1.47	1.14	2.60	0.06	T.	31.95
-89	.35	0	3.78	8.14	.58	.71	12.12	4.20	8.26	.22	.05	.06	38.47
-90	0	9.20	8.49	21.04	20.87	10.74	14.12	3.02	3.48	.08	0	T.	91.04
-91	2.29	.35	0	7.34	1.96	10.52	8.28	3.55	2.03	2.13	.83	0	39.28
-92	.30	.98	1.51	11.64	4.01	5.36	7.11	6.02	6.57	.41	0	0	43.91
-93	.51	2.51	8.21	11.88	6.91	5.80	12.94	6.69	1.44	0	T.	0	56.89
-94	1.81	1.35	8.30	5.37	11.07	12.25	4.20	2.10	4.03	1.64	T.	.51	52.63
-95	.78	4.06	1.48	17.57	18.64	5.57	4.60	3.93	3.92	0	.03	.27	60.85
-96	2.91	.17	1.61	5.87	17.77	.70	10.93	14.01	4.58	0	.11	.06	58.72
-97	1.00	.49	13.42	5.13	3.44	15.83	11.33	2.15	.15	1.32	0	0	54.26
-98	.45	3.09	3.49	5.31	2.04	8.10	1.68	.99	2.83	1.49	T.	0	29.47
-99	.44	1.87	4.03	2.84	6.93	.83	18.06	1.15	2.41	1.15	0	.32	40.03
-1900	0	9.18	9.08	8.15	4.43	3.39	6.40	4.59	2.59	.10	.05	0	47.96
-1901	.99	5.67	9.65	3.16	9.94	12.61	1.98	6.55	.96	0	T.	.07	51.58
-2	4.12	3.98	4.72	6.08	1.15	15.75	7.54	3.90	1.04	.66	0	.15	49.09
Year mean													51.08

[a] Year incomplete.

Record of precipitation at Summit, Placer County.

[Latitude, 39° 19'; longitude, 120° 27'; elevation, 7,017 feet. Authority, Pacific Railway Syst

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	To
1870-71	0	0.24	3.22	5.11	8.44	8.39	3.38	2.77	0.31	0.89	0	0	
1871-72	0.38	.40	9.33	28.88	4.44	17.61	6.55	6.22	.33	0	0	0	
1872-73	0	0	0	7.10	2.56	18.00	6.72	2.72	1.52	0	0	0	
1873-74	0	0	0	12.68	5.00	0	0	2.22	3.33	.11	0	0	
1874-75	0	3.80	2.63	.94	8.65	13.89	5.22	.89	1.58	2.64	0	0	
1875-76	0	0	7.22	7.78	16.28	9.67	15.33	3.33	1.11	0	0	0	
1876-77	.56	8.18	.53	.22	17.89	.64	3.82	.31	4.03	.02	1.26	0.10	
1877-78	.30	.59	3.69	2.50	14.11	13.58	3.38	2.67	1.61	0	0	.09	
1878-79	.44	1.35	.89	1.66	11.51	9.33	23.37	5.02	2.83	.11	0	0	
1879-80	0	1.55	6.22	17.00	7.33	8.33	9.99	33.71	3.86	0	0	0	
1880-81	0	0	.55	6.89	8.00	4.67	1.67	1.11	.05	.52	0	0	
1881-82	.60	3.38	3.40	9.52	8.01	10.00	10.33	3.61	.66	0	0	0	
1882-83	.75	13.26	4.89	5.50	1.11	2.88	8.50	3.77	3.66	0	0	0	
1883-84	.10	1.06	1.33	3.55	8.44	14.11	10.11	14.00	.82	4.10	0	0	
1884-85	1.10	3.13	0	9.40	1.40	.58	.10	4.88	1.00	.80	0	T.	
1885-86	.05	0	13.60	3.00	13.90	1.40	7.80	6.40	.95	0	0	0	
1886-87	0	3.10	1.70	5.75	6.25	20.70	1.40	5.80	.95	1.60	.10	T.	
1887-88	T.	.07	1.50	11.60	9.20	1.29	8.05	2.30	1.04	3.72	3.50	.5	
1888-89	0	0	1.90	5.26	1.00	1.50	9.55	1.90	6.30	.22	0	0	
1889-90	0	5.65	6.80	18.50	19.20	11.60	14.00	0	.80	0	0	0	
1890-91	0	0	0	7.40	1.50	1.38	5.10	4.60	1.10	0	0	0	
1891-92	1.20	.05	.30	11.90	4.00	3.40	7.40	4.50	6.30	.20	0	0	
1892-93	0	.60	8.80	9.50	7.90	10.80	14.50	9.20	0	0	0	0	
1893-94	0	.30	0	6.00	15.50	15.25	3.40	4.30	2.40	0	0	0	
1894-95	.95	1.28	.53	9.53	25.80	4.20	4.70	2.50	2.40	0	0	0	
1895-96	.20	0	1.40	8.30	10.50	.70	9.70	18.20	5.40	0	.21	.02	
1896-97	.40	.90	12.30	4.10	4.05	14.35	18.00	1.25	0	.70	0	0	
1897-98	.03	2.50	26.50	4.20	4.00	7.10	5.20	.80	2.90	.90	0	0	
1898-99	0	4.40	2.50	3.60	12.70	5.20	15.75	1.75	3.60	.70	0	1.00	
1899-1900	0	16.05	9.15	7.90	5.25	4.75	8.15	4.80	3.97	.50	.25	T	
1900-1901	.95	3.50	6.90	3.50	11.30	14.20	4.50	5.50	1.00	0	0	0	
1901-2	1.40	4.20	4.70	2.80	4.00	16.30	8.90	3.00	1.10	.30	0	1.0	
32-year mean													

Record of precipitation at Towles, Placer County.

atitude, 39° 18′; longitude, 120° 38′; elevation, 3,704 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
5–86	0.80	0	14.40	7.00	9.80	0.50	5.10	8.80	0	0	0	0	41.40
6–87	0	0.80	.80	8.00	4.85	11.60	1.10	1.20	T.	0	T.	0	22.85
7–88	0	0	.90	1.06	20.14	1.71	0	0	0	1.06	0.08	0	24.95
8–89	0	1.11	1.08	1.01	.45	.90	.60	0	0	0	0	0	5.15
9 90	0	6.03	4.11	11.40	19.40	14.60	3.00	0	1.00	0	1.00	0	60.54
0-91	.10	1.02	8.10	8.03	1.81	14.65	10.52	2.59	2.86	2.52	1.40	0	53.60
1-92	1.08	1.72	2.23	11.18	4.95	7.16	9.32	7.78	8.10	.75	0	0	54.27
2-93	.93	2.74	12.54	17.33	9.06	8.65	16.61	7.98	2.34	0	0	0	78.18
3-94	2.75	1.76	10.62	6.78	13.76	10.10	5.39	2.42	2.06	2.15	0	0	57.79
4-95	1.20	5.60	1.60	13.88	19.05	7.24	4.60	5.15	4.76	0	0	0	63.08
5-96	4.25	.80	2.16	7.61	21.34	1.08	14.08	15.66	7.21	0	T.	0	74.14
6-97	8.04	1.08	3.12	6.07	5.25	13.34	5.48	2.48	.30	1.30	0	0	46.46
7-98	.10	1.78	9.29	4.61	2.95	8.29	.50	.50	3.18	2.09	0	0	33.29
8-99	.48	2.85	5.35	3.36	8.54	.90	19.51	1.48	2.49	1.60	0	1.14	47.70
9-1900	0	9.08	10.90	10.64	8.04	19.06	3.07	1.02	.10	0	0	0	61.91
0-1901	.10	8.16	18.06	11.60	5.99	14.16	6.08	0	1.10	0	0	0	65.25
1-2	20.01	1.10	19.10	15.91	1.75	22.25	1.11	.50	1.52	0	0	0	82.25
-year mean													51.54

Record of precipitation at Laporte, Plumas County.

[Latitude, 39° 41′; longitude, 120° 59′: elevation, 5,000 feet. Authority, Weather Bureau.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
93–94								3.05	2.00	3.49	T.	0.17	[a]8.71
94–95	1.13	8.87	1.32	15.47	22.01	6.65	6.12	4.00	8.55	0	1.41	.29	75.82
95–96	8.42	.69	3.35	9.98	32.43	2.84	16.20	16.63	9.32	.09	.31	.25	100.51
96–97	2.29	3.09	28.87	12.88	6.04	17.92	13.51	3.12	0.71	3.94	0	T.	87.37
97–98	1.26	4.84	9.34	6.63	2.53	13.04	1.62	1.49	4.64	2.73	T.	.04	48.16
98–99	0.94	3.31	6.67	3.36	12.95	2.96	25.26	2.92	4.43	1.48	0	.82	64.83
99–1900	0	18.30	15.96	16.23	11.95	5.66	12.24	6.51	2.57	.36	.06	T.	89.84
00–1901	.61	13.02	14.30	8.79	17.25	18.35	6.24	7.48	2.09	T.	T.	.05	88.18
01–2	5.26	4.82	9.10	8.16	2.64	33.50	10.09	9.59	2.28	.64	.02	T.	86.10
year mean													80.10

[a] Year incomplete.

Record of precipitation at Mumford Hill, Plumas County.

[Latitude, 39° 53′; longitude, 121° 05′; elevation, 4,750 feet. Authority, J. A. Edman, Mary Valley.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1876-77					11.40	5.00	5.13	2.50	3.00	1.72	0.52	0
1877-78	0	1.10	3.05	2.10	18.15	26.52	9.44	2.10	1.85	0	.30	0.70
1878-79	2.10	2.75	5.15	3.75	12.38	12.62	30.15	6.53	3.60	1.13	0	.29
1879-80	0	4.01	7.20	14.16	10.06	7.96	5.18	23.54	6.42	0	0	.90
1880-81	0	0	.76	24.34	16.57	13.28	3.60	3.21	.84	.54	0	0
1881-82	1.36	3.28	4.32	11.23	9.94	8.60	10.75	7.48	2.05	0	0	0
1886-87												
1889-90	1.50	18.77	10.83	29.40	31.33	18.44	20.25	6.33	2.00	0	0	0
1890-91	1.50	.75	1.10	8.18	2.00	22.65	7.90	3.17	2.39	1.95	1.25	0
1891-92	.50	1.50	2.08	13.60	5.45	5.12	5.40	6.35	6.08	0	0	0
1892-93	.32	2.61	22.70	24.98	11.47	13.07	13.89	8.43	3.23	.16	0	0
1893-94	1.79	1.27	9.46	4.40	17.46	16.48	7.04	3.94	2.85	2.26	0	1.46
1894-95	1.17	6.54	2.26	24.00	26.11	5.83	10.59	3.80	7.18	0	0	.25
1895-96	9.35	1.13	3.48	9.22	32.70	1.20	13.33	16.25	7.20	0	.08	.25
1896-97	1.43	2.53	16.64	11.13	5.44	13.80	12.07	1.59	.06	2.14	0	0
1897-98	.70	3.78	8.17	5.21	1.73	12.74	1.41	1.25	4.94	2.11	0	0
1898-99	.26	2.27	4.10	1.94	13.12	3.01	17.04	2.35	2.92	.64	0	1.64
1899-1900	0	15.38	13.09	11.89	10.99	3.10	8.95	6.24	1.63	.61	0	.06
1900-1901	.20	12.51	13.13	7.70	16.79	15.36	4.94	5.62	1.34	0	0	.50
1901-2	4.86	4.27	8.85	6.81	2.38	25.42	10.60	6.77	2.49	0	.13	.12
19-year mean												

[a] Year incomplete.

Record of precipitation at Banning, Riverside County.

[Latitude, 33° 56′; longitude, 116° 55′; elevation 2,317 feet. Authority, Pacific Railway Sys-

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1878-79	0	0	0	1.08	2.37	0.66	0	1.48	0	0	0	0
1879-80	0	0.02	2.84	4.55	.75	1.59	2.77	2.40	0	0	0	0
1880-81	0	.52	.87									
1898-99					2.70	.72	2.14	.08	0.01	0.48	0	0
1899-1900	0	.69	2.23	.88	1.29	.05	1.19	2.22	1.80	0	0	0
1900-1901	0.10	.47	3.94	0	4.12	6.46	.81	.60	1.21	0	0	1.15
1901-2	0	1.17	.50	0	2.74	4.83	4.63	1.00	.06	T.	0.14	0
6-year mean												

[a] Year incomplete.

Record of precipitation at Beaumont, Riverside County.

titude, 33° 55′; longitude, 117° 00′; elevation, 2,530 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
-88					1.39	1.18	5.78	0.87	0.40	0	0	0.50	a10.12
-89	0	0.30	3.92	4.19	1.15	1.95	5.27	.61	.29	0	0	0	17.68
-90	0	1.53	.67	11.09	3.71	4.74	1.13	1.15	1.05	0	0.15	.15	25.40
-91	1.04	0	.43	2.74	0	8.70	1.07	1.72	2.43	0	0	.87	19.00
-92	.48	0	.23	2.43	.98	3.53	3.18	.37	1.87	0	0	0	13.05
-93	0	0	1.65	1.95	2.97	2.66	9.67	.40	0	0	0	.18	19.48
-94	0	1.45	0	4.34	.30	2.09	.35	.32	.43	0	0	0	9.28
-95	.42	0	0	8.89	11.49	2.28	2.72	1.24	T.	0	0	0	27.04
-96	0	.14	1.90	.34	1.68	.65	4.48	0	.82	0	.25	.31	10.57
-97	0	2.24	1.05	.30	5.00	5.91	4.69	0	0	0	0	0	19.10
-98	0	0	0	.43	1.58	.75	1.95	1.00	3.00	0	0	0	8.71
-99	0	0	0	1.20	2.64	1.02	1.40	.35	.10	1.07	0	0	7.78
1900	0	.88	2.85	.89	1.45	0	1.16	2.33	1.72	0	0	0	11.28
1901	.25	.38	3.98	0	4.08	4.77	.35	.35	1.80	0	0	.51	16.47
2	0	1.56	.43	0	2.51	3.59	4.14	1.07	.24	0	.05	0	13.59
ear mean													15.60

a Year incomplete.

Record of precipitation at San Gorgonio Pass, Riverside County.

atitude, 33° 54′; longitude, 117° 02′; elevation, 2,560 feet. Authority, J. J. Ring and M. Murray.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
4-75				0.40	1.00	0.60			0	T.	0	0	a2.00
5-76	0.03	0	1.33	1.23	9.31	5.54	6.26	0.99	.20	0	0.03	0.12	25.04
6-77	.19	.18	0	0	5.55	2.08	3.93	2.59	3.98	0	.30	T.	18.70
7-78	.08	1.30	.80	4.28	6.03	10.49	4.40	6.81	1.33	0.26	.03	.20	35.96
8-79	0	0	.97	.92	2.88	1.78	.55	3.23	.01	.62	0	.22	11.18
9-80	0	1.00	4.10	9.39	1.78	2.81	3.04	6.94	.14	0	T.	.09	29.29
0-81													
1-82	0	.50	1.33	10.27	2.48	1.86	3.39	3.62	.35	0	.94	0	24.74
2-83	0	.53	1.33	.42	3.90	7.29	4.38	4.21	.35	1.30	0	.62	23.73
3-84													
4-85													
5-86					2.97	1.73	3.07	1.24	0	0	0	0	a9.01
6-87	0	0	.58	3.36	.06	5.07	.08	2.94	.14	0	.07	0	12.30
7-88	0	1.23	1.51										a2.74
ear mean													22.62

a Year incomplete.

Record of precipitation at Whitewater, Riverside County.

atitude, 33° 54′; longitude, 116° 39′; elevation, 1,123 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
77-78	0	0	0	1.30	1.40	0.98	0.45	2.35	0	0	0	0	6.48
78-79	0	T.	.18	.46	1.30	.28	.34	.30	0	0	0	0	2.86
79-80	0	0	1.62	2.08	.51	.42	.20	.12	0.01	0	0	0.25	5.21
80-81	0	0 15	.34	1.70	0	0	2.25	.01	0	0	0	.46	4.91
81-82	0	T.	0	0	0	.48	.20	.16	0	0	0	0	.84
82-83	0	0	.57	0	.15	.34	.80	.55	0	0	0	0	2.41
83-84	0	.78	0	1.92	1.10	6.96	3.05	0	0	0	0	0	13.81
ear mean													5.22

NOTE.—Whitewater ceased reporting after August, 1884.

Record of precipitation at Sacramento, Sacramento County.

[Latitude, 38° 35′; longitude, 121° 30′; elevation, 71 feet. Authority, Signal Service and Weather Bureau.]

Year.	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr	May.	June.	July.	Aug.	
1849-50	0.25	1.50	2.25	12.50	4.50	0.50	10.00	4.25	0.25	0	0	0	
1850-51	0	0	0	0	.65	.35	1.88	1.14	.69	0	0	0	
1851-52	1.00	.18	2.14	7.07	.58	.12	6.40	.19	.30	0	0	0	
1852-53	0	0	6.00	13.41	3.00	2.00	7.00	3.50	1.45	0	0	0	
1853-54	0	.01	1.50	1.54	3.25	8.50	3.25	1.50	.21	0.31	0	0	
1854-55	0	1.01	.65	1.15	2.67	3.46	4.20	4.32	1.15	.01	0	0	
1855-56	0	0	.75	2.00	4.92	.69	1.40	2.13	1.84	.03	0	0	
1856-57	0	.20	.65	2.40	1.38	4.80	.67	0	0	.35	0.01	0	
1857-58	0	.66	2.41	6.63	2.44	2.46	2.88	1.21	.20	.10	0	0	
1858-59	0	3.01	.15	4.34	.96	3.91	1.64	.98	1.04	0	.08	0	
1859-60	.02	0	6.48	1.83	2.31	.93	5.11	2.87	2.49	.02	.55	0	
1860-61	.06	.91	.18	4.28	2.67	2.92	3.32	.48	.59	.13	0	0	
1861-62	0	0	2.17	8.64	15.04	4.26	2.80	.82	1.81	.01	0	0.01	
1862-63	0	.36	0	2.33	1.73	2.75	2.36	1.69	.35	0	0	0	
1863-64	0	0	1.49	1.82	1.08	.19	1.30	1.08	.74	.09	0	0	
1864-65	0	.12	6.72	7.87	4.78	.71	.48	1.37	.46	0	0	0	
1865-66	.08	.48	2.43	.36	7.70	2.01	2.02	.48	2.25	.10	.02	0	
1866-67	0	0	2.48	9.51	3.44	7.10	1.01	1.80	.01	0	0	0	
1867-68	.01	0	3.81	12.85	6.04	3.15	4.35	2.31	.27	T.	0	0	
1868-69	0	0	.77	2.61	4.79	3.63	2.94	1.24	.65	.01	0	0	
1869-70	T.	2.12	.85	1.96	1.37	3.24	1.64	2.12	.27	T.	T.	0	
1870-71	0	.02	.58	.97	2.08	1.92	.69	1.45	.76	T.	0	0	
1871-72	T	.21	1.22	10.59	4.04	4.74	1.94	.61	.28	.02	0	0	
1872-73	T.	.22	1.93	5.39	1.23	4.36	.55	.51	0	T.	.02	T.	
1873-74	0	.31	1.21	10.01	5.20	1.86	3.05	.89	.37	T.	T.	0	
1874-75	.05	2.26	3.80	.44	8.70	.55	.80	T.	T.	1.10	0	0	
1875-76	0	.44	6.20	5.52	4.99	3.75	4.15	1.10	.15	0	.21	.02	
1876-77	T.	3.45	.30	0	2.77	1.04	.56	.19	.64	.01	T.	T	
1877-78	0	.73	1.07	1.43	9.26	8.04	3.09	1.07	.17	0	0	0	
1878-79	.29	.55	.51	.47	3.18	3.88	4.88	2.66	1.30	.13	T.	T.	
1879-80	0	.88	2.05	3.41	1.64	1.83	1.79	14.20	.76	0	T.	0	
1880-81	0	0	.05	11.81	6.14	5.06	1.37	1.64	T.	.50	T.	0	
1881-82	.30	.55	1.88	3.27	1.89	2.40	3.78	1.99	.35	.10	T.	0	
1882-83	.57	2.63	3.22	1.13	2.23	1.11	3.70	.67	2.85	0	0	0	
1883-84	.90	.97	.61	.44	3.43	4.46	8.14	4.32	.06	1.45	0	T.	
1884-85	.60	2.01	0	10.45	2.16	.49	.06	.68	T.	.11	T.	0	
1885-86	.08	.02	11.34	5.76	7.95	.29	2.68	4.08	.07	0	0	0	
1886-87	0	.68	.21	2.21	1.12	6.28	.94	2.53	T.	0	0	T.	
1887-88	.02	0	.45	2.09	4.81	.57	3.04	.10	.40	.08	T.	T.	
1888-89	.55	0	4.28	4.63	.15	.33	6.25	.26	3.25	.25	0	0	
1889-90	0	6.02	3.15	7.82	6.62	4.06	3.00	1.33	1.80	0	0	T.	
1890-91	.80	T.	0	3.34	.53	6.61	1.78	2.04	.66	.05	T.	0	
1891-92	.10	.10	.46	3.28	1.78	2.84	3.02	1.20	2.38	T.	0	0	
1892-93	.15	.70	6.60	4.90	3.27	2.66	3.51	1.08	1.05	0	T.	T.	
1893-94	.22	.12	2.92	1.76	4.17	3.92	.74	.34	1.70	.46	T.	T	
1894-95	.88	1.06	.48	8.86	8.42	1.84	1.20	.86	.51	0	.04	T.	
1895-96	1.26	.17	1.54	1.54	9.76	.09	2.57	5.34	.92	0	T.	.30	
1896-97	.31	.55	3.56	1.76	3.66	4.15	2.54	.25	.30	.04	0	.06	
1897-98	.16	1.96	.61	1.64	.98	3.19	.04	.28	1.50	.14	0	0	
1898-99	.36	.64	.61	2.30	3.94	.04	6.02	.10	.54	.49	0	.02	
1899-1900	0	4.46	2.62	2.91	3.54	.82	1.61	1.88	2.88	T.	T.	0	
1900-1901	0	1.74	4.50	1.38	3.70	5.32	.48	2.23	.80	T.	T.	T.	
1901-2	.56	1.56	2.68	1.19	.95	6.52	1.99	1.86	.45	.01	0	T	
53-year mean													

Record of precipitation at Barstow, San Bernardino County.

atitude, 34° 51′; longitude, 116° 59′; elevation, 2,150 feet. Authority, W. L. Burbeck, Geo. R. Gooding, G. W. Fetts, and others.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
8–89					0.14	0.04	0.93	0	0.12	0	0	0.13	[a]1.36
9–90	0.07	0.23	0.70	3.87	.36	.15	T.	.07	0	0	0	.15	5.60
0–91	.59	0	.05	.52	0	2.47	T.	.05	T.	0	T.	.06	3.74
1–92	.08	0	T.	.25									[a].33
2–93					.11	.27	.77	.06	T.	0	1.10	0	[a]2.31
3–94	0	.22	T.	.72	.02	.21	.06	0	.22	T.	T.	0	1.45
4–95	0	0	0	.92	1.06	0	.20	0	0	0	0	0	2.18
5–96	0	.33	T.	0	.16	0	.06	0	0	0	.07	.87	1.51
6–97	0	1.55	.25	.30	2.15	.65	.11	0	0	T.	0	.18	5.19
ear mean													3.28
1–2							0	0	0	0	0	0	[a]0

[a] Year incomplete.

Record of precipitation at Deep Creek, San Bernardino County.

atitude, 34° 15′; longitude, 17° .07′; elevation, 5,200 feet. Authority, Arrowhead Reservoir Company.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
93–94	1.95	1.19	1.20	4.16	1.94	1.89	2.75	0.70	1.01	0.12	0.09	0.80	17.80
94–95	.49	.30	0	18.41	13.14	2.13	7.21	1.36	0	0	0	0	43.04
95–96	0	0	2.45	1.09	1.86	.05	3.52	1.75	.28	0	0	.78	11.78
96–97	0	2.28	1.65	2.41	5.43	13.03	7.59	0	.19	.10	0	0	32.68
97–98	.28	3.92	1.17	1.40	4.20	1.10	1.89	.17	2.93	.05	.11	.55	17.77
98–99	0	0	.53	.49									[a]1.02
99–1900					1.40	.28	3.07	2.70	4.75				[a]12.20
year mean													24.61

[a] Year incomplete.

Record of precipitation at Bear Valley dam, San Bernardino County.

[Latitude, 34° 15′; longitude, 116° 58′; elevation, 6,500 feet.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
83–84													94.60
84–85													28.06
85–86													65.51
86–87													24.00
87–88													62.30
88–89													46.03
89–90													93.40
90–91													78.40
91–92													38.00
92–93													44.32
0-year mean													57.46

Record of precipitation at Glen Ranch, San Bernardino County.

[Latitude, 34° 50′; longitude, 117° 30′; elevation, 3,112 feet. Authority, Jas. M. Applewhite (...)]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Tot...
1899-1900	0.10	0.03	0.96	1.00	2.15	0.10	3.84	1.35	1.69	0.02	0.01	0	...
1900-1901	.31	.46	9.39	0	6.53	9.78	.43	1.40	.96	0	0	0	...
1901-2	0	2.61	.58	.10	1.73	3.67	5.54	.53	0	.24	0	0	...
3-year mean													...

Record of precipitation at Holcomb Creek, San Bernardino County.

[Latitude, 34° 17′; longitude, 117° 05′; elevation, 5,220 feet. Authority, Arrowhead Reservoir Company.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Tot...
1894-95					10.06	0.61	4.86	0.62	0	0	0	0	...
1895-96	0	0	1.66	0.41	1.56	T.	3.24	1.02	0.25	0	0	0.47	...
1896-97	0	1.70	1.05	1.82	3.35	7.89	3.42	0	.11	0.20	0	0	...
1897-98	0.38	3.32	1.09	.90	3.05	.52	1.27	.10	1.46	0	0	.65	...
1898-99	0	0	.57	.48									...
1899-1900					.38	.21	1.14	1.25	1.20				...
3-year mean													...

[a] Year incomplete.

Record of precipitation at Little Bear Valley, San Bernardino County.

[Latitude, 34° 15′; longitude, 117° 13′; elevation, 5,150 feet. Authority, Arrowhead Reservoir Company.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Tot...
1893-94	1.21	1.49	2.55	7.61	2.48	2.25	3.16	0.62	1.34	0.12	0.04	0.5	...
1894-95	.52	.38	0	20.12									...
1896-97													...
1897-98					3.80	1.38	2.40	.25	4.56		0		...
1898-99		T.	.62	.74									...
1899-1900					1.39	.43	3.42	3.11	4.68				...

[a] Year incomplete.

Record of precipitation at Mill Creek "A," San Bernardino County.

[Latitude, 34° 05′; longitude, 116° 54′; elevation, 5,000 feet. Authority, Redlands Electric Light and Power Company.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Tot...
1899-1900					2.52	0.43	2.26	4.49					...
1900-1901			9.05		4.32	6.00	.71	.39	1.85	0	0	1.20	...
1901-2	0	1.95	.82	0									...

[a] Year incomplete.

Record of precipitation at Mill Creek "B," San Bernardino County.

Latitude, 34° 04′; longitude, 116° 58′; elevation, 2,915 feet Authority, Redlands Electric Light and Power Company.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
99–1900	.....	.....	.....	.....	1.41	0.07	1.43	3.74	3.31	0	0	0	[a]9.96
00–1901	1.14	1.15	4.96	0	.....	.....	.....	.....	.....	.....	.....	.....	[a]7.25

[a] Year incomplete.

Record of precipitation at Morse's house, San Bernardino County.

Latitude, 34° 12′; longitude, 117° 12′; elevation, 5,350 feet. Authority, Arrowhead Reservoir Company.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
93–94	0.25	2.44	2.75	14.73	4.78	3.93	5.00	1.37	2.08	0.60	0.02	0.74	38.69
94–95	.67	.47	0	26.77	18.00	5.85	12.54	2.91	0	0	0	0	67.21
95–96	0	0	4.18	3.11	5.95	.08	7.90	2.63	.89	0	0	.46	25.20
96–97	0	3.83	1.96	2.73	9.34	20.14	15.61	.15	.18	.40	0	0	54.34
97–98	.73	5.08	1.93	1.85	6.37	2.96	4.22	.70	8.27	.25	.08	.30	32.74
98–99	.....	.34	.74	1.28	.....	.....	.....	.....	.....	.....	.....	.....	[a]2.36
99–1900	.....	.....	.....	.....	2.20	.44	3.83	5.81	8.64	.....	.....	.....	[a]20.92
year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	43.64

[a] Year incomplete.

Record of precipitation at Rancho del Jurupa, San Bernardino County.

Latitude, 34° 02′; longitude, 117° 27′; elevation, 1,000 feet. Authority, United States post hospital.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
82–83	0	0	2.89	7.50	0.25	0.67	3.15	0.33	1.14	0	0	0.18	16.11
83–84	0	0	.44	2.04	1.64	2.34	3.09	.....	.....	.....	.....	.....	[a]9.55

[a] Year incomplete.

Record of precipitation at Redlands, San Bernardino County.

Latitude, 34° 03′; longitude, 117° 10′; elevation, 1,335 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar	Apr.	May.	June.	July.	Aug.	Total.
88–89	0	0.05	4.12	4.64	0.68	1.47	5.70	0.99	0.58	0	0	0.28	18.51
89–90	0.31	1.50	.52	13.72	4.69	3.03	.89	.16	.68	0	0	2.16	27.66
90–91	.88	29	0	3.02	0	9.28	1.19	.91	1.10	0.23	0	1.63	18.53
91–92	.97	0	0	1.51	.87	4.37	2.06	.13	0	0	0	0	9.91
92–93	.03	0	.46	1.14	2.39	2.65	6.26	.05	0	0	.03	0	13.01
93–94	.18	1.00	.05	2.59	.67	.90	.59	.31	.62	0	0	.11	7.02
94–95	.10	.08	0	4.35	6.54	1.12	2 74	0	.45	0	0	0	15.38
95–96	0	.03	1.17	.33	1.29	.06	2.47	.43	.85	0	0	1.03	7.66
96–97	0	1.72	2.07	.16	4.33	3.89	1.92	.10	.19	0	0	0	14.38
97–98	.83	1.92	.07	.51	2.56	.60	.84	.18	1.59	0	0	T.	9.10
98–99	.01	.01	.25	.40	1.92	.71	1.50	.08	.24	.87	0	.04	6.03
99–1900	.05	.65	1.28	.46	1.20	T.	.78	2.03	1.41	0	.04	0	7.90
900–1901	.50	.53	3.88	0	2.25	3.79	.48	T.	1.62	.04	0	0	13.07
901–2	0	.92	.09	T.	1.64	2.58	2.82	.36	.08	.31	.07	0	8.87
4-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.64

Record of precipitation at Rings Station, San Bernardino County.

[Latitude, 34° 02′; longitude, 116° 46′; elevation, 4,300 feet. Authority, John J. Ring.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1874–75	0.09	0.61	2.55	0.78	5.64	2.08	0.58	0.37	0	0	0	0	[illegible]
1875–76	.43	T.	4.06	.25	9.31	5.54	6.23	.99	0.20	0	0.03	0	[illegible]
1876–77	.19	.18	0	0	5.75	2.33	3.93	2.59	3.93	0	.30	0	[illegible]
1877–78	0	1.30	0.80	4.03	6.03	10.49	4.41	6.86	1.33	0.26	.03	0.37	[illegible]
1878–79	0	0	.97	1.52	2.88	5.11	.55	3.23	0	0	0	0	[illegible]
1879–80	0	1.00	4.10	9.39	1.78	2.81	3.04	1.39	.14	0	0	0	[illegible]
1880–81	0	.50	1.05	10.27	2.48	1.86	3.39	2.93	.35	0	.94	0	[illegible]
1881–82	0	1.30	.08	.42	3.30	7.29	5.38	4.21	.35	1.30	0	0	[illegible]
8-year mean													[illegible]

Record of precipitation at Santa Ana Canyon, San Bernardino County.

[Latitude, 34° 09′; longitude, 117° 07′; elevation, 3,000 feet. Authority, Edison Electric Company.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1899–1900							0.74	5.87					[illegible]
1900–1901					5.53	7.82	1.10	1.38	1.36				[illegible]

[a] Year incomplete.

Record of precipitation at Squirrel Inn, San Bernardino County.

[Latitude, 34° 12′; longitude, 117° 15′; elevation, 5,300 feet. Authority, Arrowhead Reservoir Company.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1893–94	0.38	1.90	5.00	8.93	4.00	3.23	3.54	1.17	1.37	0.23	0	0.62	[illegible]
1894–95	.50	.34	0	16.38	14.22	5.85	9.58	2.53	0	0	0	0	[illegible]
1895–96	0	0	2.92	1.98	4.51	0	5.60	.98	.89	0	0	.38	[illegible]
1896–97	0	3.20	1.60	2.23	7.65	13.31	12.17	.13	3.03	.20	0	0	[illegible]
1897–98	0	0			4.98	1.95	2.98	.68	6.50		0		[illegible]
1898–99	.05	.37	.70	1.35									[illegible]
1899–1900					1.73	.26	3.04	4.81	6.37				[illegible]
4-year mean													[illegible]

[a] Year incomplete.

Record of precipitation at Upper Holcomb Valley, San Bernardino County.

[Latitude, 34° 18′; longitude, 116° 55′; elevation, 7,200 feet. Authority, Arrowhead Reservoir Company.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1897–98					2.60	0.40	1.50	0.50					[illegible]

[a] Year incomplete.

Record of precipitation at Campo, San Diego County.

[Latitude, 32° 37′; longitude, 116° 30′; elevation, 2,660 feet. Authority, A. Campbell, Campo.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
76–77	.....	.....	.....	.....	.....	.....	2.29	1.08	0.91	0	0.50	0	[a]4.78
77–78	0	0.35	1.50	2.44	1.79	5.45	1.84	5.75	.41	0	2.32	0.01	21.86
78–79	0	.31	.55	1.29	2.18	1.32	.60	2.01	0	0	0	0	8.26
79–80	0	0	3.00	2.23	3.00	2.15	3.56	4.00	0	0	.12	.41	18.47
80–81	0.01	.68	.85	4.85	1.74	.53	5.00	1.52	.12	0.04	.07	1.27	16.68
81–82	.02	.73	.11	.24	3.10	4.57	1.01	1.10	.18	.26	.62	.53	12.47
82–83	.02	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[a].02
88–89	.....	.....	.....	.....	.....	4.65	4.00	.....	.45	.10	.....	2.50	[a]11.70
89–90	.50	1.10	1.67	9.34	2.40	7.25	1.69	1.86	.90	.16	2.26	2.67	31.80
90–91	1.80	.44	.95	2.80	0	13.30	.50	1.20	.75	0	0	[b]16.10	37.84
91–92	0	0	.25	3.21	.75	4.55	3.30	1.25	2.75	.35	0	0	16.41
92–93	0	.12	.71	.50	3.55	3.65	7.19	1.54	.41	0	0	0	17.67
93–94	.57	.11	3.38	2.08	5.89	5.83	1.01	.80	4.38	1.26	0	0	25.31
99–1900	.24	.60	1.61	1.15	2.65	.10	.55	2.07	1.04	.10	0	0	10.11
00–1901	.05	.28	4.47	0	2.09	8.22	.69	.54	1.18	0	.61	.63	18.70
01–2	0	1.02	.43	.23	4.28	4.72	4.00	1.33	.07	.12	2.24	0	18.44
7-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.54

[a] Year incomplete. [b] Cloudburst; rain gage washed away. Record incomplete.

Record of precipitation at Cuyamaca Reservoir, San Diego County.

atitude, 33° 00′; longitude, 116° 40′; elevation, 4,800 feet. Authority, San Diego Flume Company.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
87–88	0	0.78	3.64	6.00	3.35	3.12	4.12	0.21	0	0	0.98	0.04	22.19
88–89	0.21	3.82	8.38	13.30	2.99	4.70	12.85	3.44	2.22	0	0	1.71	53.57
89–90	.03	3.82	1.64	20.96	8.05	16.36	4.00	1.02	3.92	0	.09	.90	60.79
90–91	1.45	.58	3.62	12.14	0	34.70	3.17	3.50	3.69	0	.04	.30	63.19
91–92	.69	0	.45	6.75	7.23	6.47	7.76	3.35	5.90	0.67	0	0	39.27
92–93	0	.30	2.87	3.76	5.55	9.13	15.60	1.00	1.00	0	1.20	.30	40.71
93–94	0	1.90	3.30	2.75	2.05	2.05	0	0	1.00	.50	0	.50	14.05
94–95	.30	0	0	12.80	28.43	4.60	5.89	1.10	1.16	0	0	0	54.28
95–96	3.00	1.03	6.01	1.66	5.77	.20	3.01	1.78	.92	0	1.29	.87	25.54
96–97	1.08	4.98	3.45	3.74	6.32	8.14	8.56	.22	.38	0	0	0	36.80
97–98	.36	5.09	1.07	2.46	5.47	1.97	4.06	1.24	5.97	0	0	1.32	29.01
98–99	0	0	.88	.96	7.02	1.53	7.23	.98	.47	2.96	.04	T.	22.07
99–1900	0	4.51	3.45	2.49	3.62	.26	2.51	6.69	2.81	.10	.28	0	26.72
00–1901	.92	.74	11.97	.04	8.17	13.26	2.32	1.24	3.87	0	T.	.09	42.62
01–2	.08	1.94	1.48	.52	8.17	5.70	13.82	2.09	.14	.17	1.54	0	35.65
7-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	37.76

Record of precipitation at Descanso, San Diego County.

atitude, 32° 50′; longitude, 116° 40′; elevation, 3,500 feet. Authority, E. W. Hulburd, Descanso.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
95–96	T.	0.38	4.37	1.00	2.98	0.10	8.04	1.14	0.17	0	0.30	1.38	19.81
96–97	0.03	2.71	2.12	2.43	6.48	6.27	5.21	.16	.21	0.01	.62	.04	26.29
97–98	.56	2.83	.40	2.90	5.28	.89	4.11	.90	2.35	0	.15	.83	21.20
98–99	0	0	.35	1.00	3.49	1.69	2.73	.25	1.45	0	.15	.38	11.49
99–1900	0	1.62	.25	1.06	4.00	.75	1.25	4.25	2.69	.06	0	T.	15.93
00–1901	.25	.63	6.50	.15	3.25	11.00	1.40	.57	1.53	0	T.	.78	26.06
01–2	T.	1.25	.87	.12	4.47	4.52	8.00	1.50	.06	0	.45	0	21.24
year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20.29

Record of precipitation at Julian, San Diego County.

[Latitude, 33° 04′; longitude, 116° 36′; elevation, 4,500 feet. Authorities, J. S. Beck and Mrs. L. Harritt.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1879–80	0	0	2.13	4.50	1.50	5.75	9.25	7.50	0	0	0	0	30.63
1880–81	0	0	2.25	2.75	5.13	4.88	8.13	2.75	0	0	0	0	25.89
1881–82	0	0	1.88	6.88	5.13	8.38	7.13	4.88	0	0	0	0	34.28
1882–83	0	0	5.13	6.25	10.04	6.63	9.13	4.13	0	0	0	0	41.31
1883–84	0	2.75	0	6.00	2.25	20.63	15.63	10.63	3.63	0	0	0	61.52
1889–90	.....	.....	.....	.....	6.12	10.39	3.63	1.11	2.54	0	0	1.25	25.04
1890–91	1.25	0	2.00	6.36	.07	19.32	2.09	2.66	3.00	0	0	.89	37.84
1891–92	.81	0	2.25	8.61	6.17	6.69	1.54	6.11	3.55	0.41	0	.11	36.25
1892–93	0	.56	1.53	2.81	3.76	3.72	14.42	.66	.62	0	1.65	.42	30.15
1893–94	.03	2.20	3.25	4.00	4.40	2.77	4.19	.32	.68	.04	.17	.34	22.39
1894–95	.21	T.	0	9.38	16.32	3.80	5.04	.95	.45	T.	T.	.70	36.85
1895–96	0	.70	2.60	.75	4.55	.40	6.10	1.40	.10	0	.17	.34	17.11
11-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	32.17

[a] Year incomplete.

Record of precipitation at Laguna, San Diego County.

[Latitude, 32° 50′; longitude, 116° 31′; elevation, 5,440 feet. Authority, Arch. Campbell, Cas...]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1884–85	.....	.....	.....	.....	.....	.....	.....	2.10	1.36	0.17	0	1.57	.....
1885–86	.....	0.44	2.71	0.60	.....	.....	.....	.....	.....	0	0.21	2.43	.....
1886–87	0	.29	1.40	0	.....	.....	.....	.....	.....	.....	.....	.....	.....
1890–91	.....	.....	.....	.....	.....	.....	.....	.....	.60	0	1.15	2.83	.....
1894–95	.....	.....	.....	9.97	17.44	2.87	2.70	0	.45	0	0	0	33.43
1895–96	0		6.40		3.55		5.60	1.55	.25	0	1.50	3.85	22.70
1896–97	0	3.35	2.48	2.74	3.60	1.08	.....	.....	.....	.....	.....	.....	.....
1897–98	0.03	2.50	0	1.80		8.10		4.44	0	0	0		.....
1898–99	0	0	.....	.....		16.00			0	0	0	0	.....
1899–1900	0	1.85	2.70	1.65	3.30	.37	1.00	3.80	2.19	.30	0	0	.....
1900–1901	.20	.40	6.20	0	5.60	8.60	.95	.71	2.09	0	.42	1.25	26.42
1901–2	0	1.42	.54	.35	.40	.35	6.15	1.05	.11	.21	2.32	.48	.....
5-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

[a] Year incomplete.

Record of precipitation at Nellie, San Diego County.

[Latitude, 33° 20′; longitude, 116° 55′; elevation, 5,240 feet. Authority, N. A. Clark.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1901–2	.....	2.55	1.75	0.55	17.60	7.34	10.21	2.20	0.25	0	0.06	0	42.51

[a] Year incomplete.

Record of precipitation at San Diego, San Diego County.

Latitude, 32° 45′; longitude, 117° 8′; elevation, 69 feet. Authorities, U. S. War Department and Weather Bureau.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1849–50	.....	.....	.....	.....	0	1.13	1.00	0.09	0	0.68	0	0	[a]2.90
1850–51	0	0.19	2.82	1.93	0.03	1.51	.34	.87	0.71	.01	0	0	8.41
1851–52	0.02	.01	.25	3.74	.58	1.84	1.87	.85	.32	0	0	0.40	9.88
1852–53	0	.06	1.45	4.50	.50	.20	1.52	.25	2.10	.05	0	.21	10.84
1853–54	0	0	1.28	1.77	.99	2.56	1.88	.89	.18	.01	0.07	1.36	10.99
1854–55	.09	.27	.04	3.29	1.97	3.59	1.30	1.52	.06	0	0	.04	12.17
1855–56	0	.11	2.15	.41	1.27	1.86	1.59	2.17	.29	0	0	0	9.85
1856–57	.07	0	1.22	1.30	.26	1.76	0	.04	.08	.03	0	.02	4.78
1857–58	.01	.49	2.16	1.30	1.52	.44	1.24	.17	0	.19	0	.04	7.56
1858–59	.10	.47	.28	3.10	0	1.89	.20	.36	.17	0	.02	0	6.59
1859–60	0	.18	1.49	1.79	.72	1.49	.15	.65	.04	.05	.14	0	6.70
1860–61	0	0	2.88	2.99	.82	.79	.05	.04	0	.19	0	0	7.76
1861–62	1.59	.05	1.19	3.20	5.56	1.39	.97	1.05	.16	.48	.11	0	15.75
1862–63	0	.89	.05	.93	.32	1.09	.33	.13	.02	0	0	0	3.76
1863–64	.36	0	.73	.04	.04	2.50	.20	.01	1.25	.01	.11	0	5.25
1864–65	0	.04	2.41	1.04	1.28	3.00	0	.56	0	.01	1.29	0	9.63
1865–66	0	.02	.52	.84	5.05	3.43	1.47	.11	.09	0	0	.10	11.63
1866–67	0	0	.24	1.82	2.32	.85	7.88	.48	.04	0	0	.80	13.93
1867–68	0	.34	.45	3.06	3.37	1.63	.73	1.20	.15	0	.51	0	11.44
1868–69	.05	0	2.00	1.52	2.88	1.88	1.98	.53	.33	0	.05	0	11.22
1869–70	0	.05	2.32	.94	.54	.77	.33	.20	.28	0	.04	.07	5.54
1870–71	0	1.54	.18	.42	.52	1.35	.01	.70	.34	0	0	0	5.06
1871–72	0	0	1.33	1.39	.99	2.63	.46	.26	.12	0	0	.18	7.36
1872–73	0	0	0	1.40	.44	4.15	.11	.10	.03	0	0	1.95	8.18
1873–74	0	0	.77	5.46	3.11	3.73	1.20	.34	.34	0	.12	0	15.07
1874–75	.11	.53	.88	.55	2.38	.37	.45	.12	.20	.02	0	.21	5.82
1875–76	.39	0	2.25	.41	2.47	2.44	1.78	.06	.05	.05	.03	.06	9.99
1876–77	.03	.08	.04	.15	1.05	.18	1.44	.26	.43	0	0	0	3.66
1877–78	0	.81	.06	3.89	1.45	4.83	1.41	2.91	.58	.16	0	0	16.10
1878–79	0	.96	0	1.57	3.54	1.04	.10	.60	T.	.07	0	0	7.88
1879–80	0	.29	2.77	6.30	.61	1.50	1.43	1.34	.06	.06	.09	.32	14.77
1880–81	0	.53	.28	4.15	.52	.45	1.88	1.35	.04	.05	0	.01	9.26
1881–82	.04	.24	.12	.30	4.53	2.55	1.02	.45	.18	.07	0	T.	9.50
1882–83	.01	.41	.39	.13	1.09	.95	.41	.31	1.14	.08	0	0	4.92
1883–84	0	2.01	.20	1.82	1.34	9.05	6.23	2.84	2.17	.31	0	T.	25.97
1884–85	.07	.35	.11	5.12	.35	.02	.78	1.20	.61	.06	T.	.13	8.80
1885–86	T.	.31	1.56	.71	6.95	1.51	3.73	1.95	.04	.07	T.	T.	16.88
1886–87	0	.05	.95	.10	.04	4.51	.02	2.14	.47	.04	.01	T.	8.33
1887–88	T.	T.	2.08	1.14	1.96	1.48	2.79	.10	.22	.04	.01	T.	9.82
1888–89	.04	.26	1.83	2.84	1.72	1.80	2.20	.19	.03	.10	T.	.04	11.05
1889–90	T.	2.12	.12	7.71	2.79	1.70	.41	.05	.08	0	0	0	14.98
1890–91	.65	.01	.72	1.61	1.21	4.84	.27	.76	.35	.05	T.	0	10.47
1891–92	.08	.04	.10	1.29	1.58	2.96	.96	.41	1.15	.13	0	.05	8.75
1892–93	T.	.22	.94	.69	.78	.47	5.50	.22	.39	T.	T.	0	9.21
1893–94	0	.11	.91	1.91	.29	.49	1.05	.11	.09	.01	0	.04	5.01
1894–95	.01	T.	0	2.26	7.33	.53	1.43	.11	.19	0	0	0	11.86
1895–96	.01	.27	1.19	.27	1.27	.02	2.89	.25	.03	.01	T.	.13	6.34
1896–97	T.	.97	.98	2.18	3.13	2.72	1.58	.02	.12	T.	.01	T.	11.71
1897–98	T.	1.06	.02	.32	1.71	.06	.91	.22	.66	.02	0	0	4.98
1898–99	.07	0	.15	.87	2.34	.30	.85	.29	.10	.27	0	07	5.31
1899–1900	0	.35	.86	.65	.09	.03	.53	1.26	1.45	.08	0	T.	5.90
1900–1901	T.	.30	1.43	0	2.08	4.77	1.07	.01	.77	.02	T.	T.	10.45
1901–2	.06	.28	.41	.02	1.70	1.57	1.86	.21	.06	T.	.92	T.	7.09
52-year mean													9.50

[a] Year incomplete.

Record of precipitation at Warners, San Diego County.

[Latitude, 33° 5′; longitude, 116° 40′; elevation, 2,894 feet. Authority, Charles E. McGary

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total
1900–1901	.....	.....	1.93	.....	2.58	5.98	0.35	0.20	0.97	.....	.....	.....	[illegible]

[a] Year incomplete.

Record of precipitation at Santa Barbara, Santa Barbara County.

[Latitude, 34° 25′; longitude, 119° 40′; elevation, 100 feet. Authority, United States War Department and Weather Bureau.

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1867–68	0	0	2.31	12.67	3.97	2.00	1.08	2.44	.72	0	0	0	[illegible]
1868–69	0	0	1.25	4.26	3.26	2.12	4.22	.46	.20	0	0	0	[illegible]
1869–70	0	0.30	.65	.57	.25	5.87	.83	.99	.74	0.07	0	0	[illegible]
1870–71	0	1.04	.27	1.41	.86	2.92	.02	2.02	.37	0	0	0	[illegible]
1871–72	0	.09	1.83	6.56	2.53	1.81	.18	1.80	0	.14	0	0.02	[illegible]
1872–73	0.05	0	0	4.34	.58	5.48	.05	0	0	0	0	0	[illegible]
1873–74	0	0	.27	5.26	4.54	3.17	.78	.28	.14	0	0	0	[illegible]
1874–75	0	1.91	1.30	0	14.84	.18	.38	.10	0	0	0	0	[illegible]
1875–76	0	0	6.53	.31	7.56	5.67	2.73	.27	0	0	0	0	[illegible]
1876–77	0	.32	0	0	2.72	0	.82	.18	.45	0	0	0	[illegible]
1877–78	0	0	1.32	3.12	7.17	11.73	2.47	3.34	.29	.07	0	0	[illegible]
1878–79	0	.32	0	5.16	5.24	.71	.34	1.60	.21	0	0	0	[illegible]
1879–80	0	.41	1.62	4.57	1.30	10.86	1.15	5.73	0	0	0	0	[illegible]
1880–81	0	.25	.28	9.73	2.83	.30	1.25	.59	0	0	0	0	[illegible]
1881–82	.44	1.47	.33	.95	1.13	2.38	5.74	1.63	0	.20	0	0	[illegible]
1882–83	0	.37	.77	.10	2.18	2.92	3.64	.29	2.79	.35	0	0	[illegible]
1883–84	0	1.32	0	2.76	6.33	9.68	9.77	2.60	.39	1.62	0	0	[illegible]
1884–85	0	1.02	.79	6.62	1.23	.07	.35	3.00	0	0	0	0	[illegible]
1885–86	0	.19	9.84	2.47	5.12	1.19	2.03	3.40	0	0	0	0	[illegible]
1886–87	0	.39	.87	.86	.31	8.64	.13	1.43	.33	.03	0	0	[illegible]
1887–88	.38	.31	1.10	4.43	10.15	1.30	3.86	.16	.02	T.	T.	T.	[illegible]
1888–89	.03	.07	5.62	5.59	.29	1.29	7.31	.49	.76	.13	0	0	[illegible]
1889–90	0	8.65	3.21	10.64	5.32	2.96	1.10	.31	.18	0	0	0	[illegible]
1890–91	1.50	0	.48	3.53	.50	8.82	1.65	1.90	0	0	0	0	[illegible]
1891–92	.18	0	0	2.26	1.04	2.48	3.36	.34	.62	0	0	0	[illegible]
1892–93	0	.42	3.70	7.31	4.52	3.55	7.53	.38	0	0	0	0	[illegible]
1893–94	0	.62	T.	3.50	.65	.50	.22	.35	.86	0	.15	0	[illegible]
1894–95	1.36	.78	.11	4.16	6.25	.67	1.90	.46	.02	.05	T.	0	[illegible]
1895–96	0	.55	.77	.93	6.84	0	2.37	1.78	.08	.05	.40	0	[illegible]
1896–97	0	.92	3.51	2.92	4.35	3.65	2.73	.02	0	0	0	0	[illegible]
1897–98	0	1.44	0	0	.63	1.39	.28	T.	1.25	0	T.	0	[illegible]
1898–99	3.17	.14	0	.86	4.48	0	2.78	.64	0	.78	0	0	[illegible]
1899–1900	0	2.06	1.97	2.35	2.32	.05	1.58	.42	1.90	.01	.02	T.	[illegible]
1900–1901	.04	.15	3.99	.02	4.86	3.65	.16	2.07	.34	.10	.06	.10	[illegible]
1901–2	.36	2.42	1.16	T.	1.36	4.40	2.89	1.40	.07	0	0	0	[illegible]
35-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

l of precipitation at Mount Hamilton (Lick Observatory), Santa Clara County.

ritude, 37° 20′; longitude, 121° 38′; elevation, 4,440 feet. Authority, Lick Observatory.]

ar.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
.....					3.11	5.99	1.13	0.98	0.09	0.33	0	0	a11.63
.....	0.10	0.33	0.91	9.72	3.55	2.90	5.40	4.70	.48	1.06	0	0	29.15
.....	0	6.16	3.45	1.93	3.10	3.75	8.66	2.66	7.56	0	0	0	37.27
.....	.65	2.60	1.48	2.05	5.60	12.76	16.35	11.96	1.24	3.85	0	0.15	58.69
.....	.65	3.71	.01	33.84	1.99	.57	1.15	2.08	.16	.36	0	0	44.52
.....	.15	.05	3.01	6.76	4.53	1.80	5.77	6.79	.70	0	0	0	29.56
.....	0	.60	2.82	2.34	2.83	7.80	1.39	5.75	.25	.30	0.04	0	24.12
.....	.33	.09	.90	11.25	10.04	1.38	3.40	.68	1.25	0	0	.02	29.34
.....	.49	.03	3.27	4.23	1.04	1.42	6.17	1.92	3.21	.05	0	0	21.83
.....	0	4.38	4.69	13.19	7.92	2.04	4.39	1.79	2.42	0	0	0	40.82
.....	.80	.02	.58	5.39	1.38	6.52	4.26	3.08	1.12	.57	0	0	23.72
.....	.28	.61	.38	9.54	1.97	2.99	5.98	1.90	3.52	.32	0	T.	27.49
.....	.24	.38	10.30	5.56	3.29	3.40	8.99	3.61	.95	.16	0	0	36.88
.....	.48	.66	4.01	3.38	8.74	10.52	2.54	.89	2.78	.64	.02	T.	34.66
.....	1.64	2.98	.84	11.90	10.00	3.08	1.46	2.80	2.39	0	.01	0	36.60
.....	.08	.78	2.46	3.16	9.54	1.08	3.83	6.70	2.10	.03	T.	.28	30.04
.....	.47	1.91	5.77	4.93	3.50	5.92	3.40	.78	.27	.39	0	0	27.34
.....	.07	1.26	1.51	2.70	1.50	4.16	2.04	.83	2.41	.38	0	0	16.86
.....	.29	1.33	1.33	2.13	5.63	.75	11.11	1.40	1.47	.39	0	.12	25.95
900.....	T.	6.37	4.92	4.16	3.26	1.70	3.37	4.06	1.35	T.	.01	.02	29.22
901.....	.08	3.48	7.76	2.21	5.74	5.92	1.98	3.33	1.07	.02	0	.05	31.64
.....	1.07	2.29	2.89	1.61	1.47	9.25	5.18	2.98	1.19	0	0	0	27.93
ar mean													31.60

a Year incomplete.

Record of precipitation at Delta, Shasta County.

itude, 41° 00′; longitude, 122° 23′; elevation, 1,138 feet. Authority, Pacific Railway System.

ear.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
83	0.10	9.20	8.14	3.94	1.00	0	14.46	8.49	9.94	0	0	0	55.27
84	0	6.18	1.10	4.24	15.57	4.55	13.44	16.55	2.73	7.12	0.25	0	71.73
85.....	1.03	6.01	.56	16.24	2.91	2.53	.37	2.54	.67	1.60	0	0	34.46
86	0	.60	29.38	12.94	9.95	.50	3.52	10.19	8.16	.60	0	0	75.84
87.	T.	1.30	.30	8.81	3.84	10.27	3.37	5.53	1.26	.82	0	0	35.50
88.....	0	0	.75	2.23	10.40	4.67	1.70	0	2.45	3.30	0	0	25.50
89.....	(0.16)	(7.14)	(7.18)	10.56	.15	1.02	37.52	2.91	5.81	1.07	0	0	73.52
90.....	0	26.71	10.03	25.83	17.18	21.11	16.50	4.78	2.33	0	0	0	124.47
91.....	1.00	.40	0	7.24	3.72	13.70	2.06	8.95	4.76	1.98	.75	0	44.56
92.....	1.31	2.24	1.99	7.21	5.55	4.01	8.34	6.31	5.22	.04	.10	0	42.32
93.....	1.52	3.40	13.08	19.51	3.17	2.10	11.90	8.90	3.30	0	T.	0	66.88
94.....	2.85	.15	8.05	3.10	14.30	3.70	2.60	2.75	3.50	2.25	0	T.	43.25
95.....	4.00	7.33	3.30	33.17	18.55	7.03	7.72	1.71	6.85	0	1.07	0	90.73
96.....	5.18	0	2.15	5.98	31.42	.60	11.81	16.72	6.92	.07	0	T.	80.85
97.	T.	3.50	12.00	17.23	4.66	7.13	4.63	1.30	0	2.75	0	0	53.20
98.....	0	3.40	3.55	6.05	.75	13.55	0	1.35	5.85	1.40	0	0	35.90
99.	0	1.95	3.35	2.00	8.19	(6.13)	11.81	.65	1.10	4.05	0	0	39.23
1900.....	0	9.85	19.60	6.40	12.25	4.60	9.45	8.59	4.10	1.56	.17	0.20	76.77
1901.....	.97	15.68	10.51	8.04	13.43	9.28	1.58	6.81	.65	0	0	0	66.95
2.....	2.28	2.95	11.27	5.55	2.92	39.82	8.48	7.70	4.02	.32	T.	.28	85.59
ear mean													61.13

Record of precipitation at Fort Crook, Shasta County.

[Latitude, 40° 10′; longitude, 121° 20′; elevation, 3,390 feet. Authority, U. S. War Departm.

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1857–58					2.23	4.38	2.57	1.28	0.13	0.34	0	0.5
1858–59	0.04	3.67	1.32	6.39	1.81	5.96	4.06	1.26	.60	0	0	.6
1859–60	1.80	0	3.85	1.00	2.14	.27	5.10	3.09	3.06	.44	2.22	0
1860–61	.23	2.97	1.33	5.04	1.20	4.78	4.03	1.82	1.33	.66	0	0
1861–62	0	.09	6.18	9.75	8.22	4.89	3.53	2.64	2.59	2.45	.02	0
1862–63	.40	.09	0	1.81	3.60	3.09	2.80	1.00	.40	0	0	0
1863–64	0	.39	.06	2.00	1.10	0	.58	1.00	1.34	.35	0	0
1864–65	0	1.05	7.00	7.47	3.16	2.16	2.23	1.20	1.30	.60	0	0
1865–66	1.02	1.55	8.75				8.25	.87				
1866–67	0	0	.80	11.75	5.27	4.44	.75	1.86	.50	.30	0	0
1867–68	.80	.78	1.12							1.67	.16	0
1868–69	0	.50	.56	3.25	2.85		4.82	1.56				
8-year mean												

[a] Year incomplete.

Record of precipitation at Redding, Shasta County.

[Latitude, 40° 36′; longitude, 122° 27′; elevation, 565 feet. Authority, Pacific Railway Syste

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1890–91					1.68	9.95	3.05	2.31	3.17	1.91	0.75	0
1891–92	0.13	0.02	0.08	8.36	1.19	1.32	1.41	2.31	3.23	.20	0	0
1892–93	0	2.46	8.96	14.27	4.18	4.75	9.17	3.94	1.35	0	0	0
1893–94	3.05	.27	7.60	3.97	9.69	7.65	3.20	2.60	1.31	.65	0	0.8
1894–95	1.59	5.85	.99	15.35	12.84	3.08	2.78	.99	2.61	0	.95	T
1895–96	3.24	.01	2.12	4.36	14.52	.79	4.17	4.05	8.97	.35	T.	0
1896–97	.81	1.99	6.30	8.98	4.42	6.80	5.29	3.02	0	1.59	0	0
1897–98	.15	1.36	1.69	3.60	.54	3.77	0	.76	3.64	.15	0	T
1898–99	.13	1.56	2.23	2.35	9.66	1.04	8.86	.61	.82	2.46	0	0
1899–1900	0	4.83	8.50	4.18	6.45	2.86	3.68	2.59	3.12	1.38	T.	0
1900–1901	2.48	6.47	3.03	3.14	6.33	5.52	.57	5.11	.41	T.	.01	T
1901–2	3.11	3.08	6.45	4.37	1.87	19.97	4.73	4.69	2.94	0	.01	0
11-year mean												

[a] Year incomplete.

Record of precipitation at Sims, Shasta County.

[Latitude, 41° 05′; longitude, 122° 21′; elevation, 1,387 feet. Authority, Pacific Railway Sy

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1887–88							4.74	1.00	2.53	4.37	0.14	
1888–89	0.10	0		9.21	0.42			1.87	3.55	2.73	0	
1889–90	0	28.57	13.32	19.85	17.84	18.30	19.83	5.53	2.64	.65	0	
1890–91	1.44	0	0	8.80	4.01	5.29	2.85	6.03	4.36	2.17	.80	
1891–92	1.50	4.08	3.51	7.36	1.12	4.39	8.81	8.39	7.27	.74	.19	
1892–93	1.24	1.64	13.39	26.92	3.50	4.39	8.94	9.67	4.57	T.	0	
1893–94				3.48	10.98	4.40	6.37	1.00	3.42	2.52	T.	
1894–95	2.80	1.65										
4-year mean												

[a] Year incomplete.

Record of precipitation at Coles, Siskiyou County.

titude, 42° 08′; longitude, 122° 39′; elevation, 2,905 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
88							1.21	0.24	1.90	2.79	0.85	T.	[a]6.99
89	0.85	0	1.43	1.32		0.15	2.20	.96	2.74	.10			[a]9.75

[a] Year incomplete.

Record of precipitation at Dunsmuir, Siskiyou County.

titude, 41° 12′; longitude, 122° 16′; elevation, 2,285 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
89	0	0	6.83	2.95	0.30	0.33	4.39	2.43	7.06	1.12	0	0	25.41
90	0	20.15	11.65	20.57	23.60	16.50	11.85	11.85	2.45	.40	0	0	119.02
91	0.90	0	0	8.05	.55	2.59	2.70	4.95	3.07	2.88	0.67	0.07	26.43
92	1.52	2.13	2.32	9.65	2.41	3.31	5.30	5.48	3.96	1.22	.35	0	37.65
93	.05	2.68	*7.47	14.03	3.65	6.40	13.30	8.75	4.06	0	.20	0	60.59
94	3.27	1.15	11.35	5.08	17.53	7.60	6.05	1.70	4.35	2.10	0	0	60.18
95	.20	9.65	2.90	29.30	15.30	6.50	8.15	2.55	4.40	0	1.55	0	80.50
96	5.75	.05	1.40	4.39	22.25	1.54	10.23	11.43	6.22	.17	.34	0	63.77
97	1.46	0	11.07	13.94	4.08	10.63	6.33	1.02	.14	2.35	0	0	51.02
98	0	2.78	4.34	4.98	9.76	10.62	0	1.20	4.20	1.50	0	0	39.38
99	.53	1.71	2.98	11.43	6.80	.50	10.31	.48	1.60	1.90	0	.90	39.14
1900	T.	7.10	15.29	7.40	9.98	3.32	6.27	4.85	3.18	.90	0	T.	58.24
1901	1.20	6.13	7.16	8.29	8.93	6.90	1.92	2.58	T.	0	0	0	43.11
2	0	0	10.88	5.06	2.69	29.40	3.76	1.21	1.74	0	T.	.05	54.79
year mean													54.23

Record of precipitation at Edgewood, Siskiyou County.

atitude, 41° 28′; longitude, 122° 23′; elevation, 2,955 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
8-89	0.89	0.15	2.00	0.75	0.30	0.10	8.43	0.69	2.30	0.11	0.33	0	16.05
9-90	0	7.80	2.35	5.30	5.60	5.90	5.04	.70	1.60	1.72	0	0.45	36.46
0-91	1.05	.22	0	3.00	.55	2.45	.18	1.96	2.04	1.45	.67	.05	13.62
1-92	.84	.43	.20	2.80	.15	.12	2.67	.86	1.63	.69	.80	0	11.19
2-93	.58	1.07	5.35	7.88	.95	.20	2.90	3.48	.95	.30	.66	0	24.32
3-94	1.51	.76	2.65	.85	5.13	.50	1.83	.15	3.56	.72	0	.46	18.12
4-95	.69	1.75	.82	9.55	4.56	.38	2.84	.08	.73	0	0	.94	22.32
5-96	1.59	.05	.75	.51	6.64	.30	2.68	4.66	1.35	.42	.07	.77	19.79
6-97	.71	.40	3.45	5.16	1.18	1.63	1.85	.15	2.03	1.78	0	.35	18.69
7-98	0	1.27	1.90	2.68	.90	4.75	.17	1.64	2.49	.51	0	.99	17.30
8-99	T.	.78	1.51	0	0	.52	1.67	.19	1.72	.29	0	.42	7.10
9-1900	0	1.87	3.79	2.21	3.37	.91	1.85	2.25	1.58	.85	.11	.23	19.02
0-1901	.68	4.97	.91	2.77	1.00	3.21	.18	1.02	.98	0	.48	.65	16.85
1-2	1.16	0	2.28	2.24	.37	7.88	2.46	3.47	.97	.10	.32	.86	22.11
year mean													18.78

Record of precipitation at Fort Jones, Siskiyou County.

[Latitude, 41° 35′; longitude, 122° 51′; elevation, 2,570 feet. Authority, U. S. War Department.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1852-53					3.78	1.38	3.39	1.02	1.17	0.41	0.13		[illegible]
1853-54	0.20	0.48	4.47	1.19	.54	2.62	.75	1.99	.21	.63	.20	0.21	[illegible]
1854-55	0	4.18	.48	1.13	1.58	3.83	5.24	1.50	.87	.08	0	[illegible]	[illegible]
1855-56	.20	1.40	1.77	6.47	1.59	.42	1.18	1.84	2.77	.60	0	.30	[illegible]
1856-57	0	.13	1.78	8.93	3.62	7.59	2.35	0	.69	1.86	0	0	[illegible]
1857-58	.60	.80	4.47	4.24	6.15	8.78	3.69	1.15	1.55	.60	0	0	[illegible]
5-year mean													[illegible]

[a] Year incomplete.

Record of precipitation at Hornbrook, Siskiyou County.

[Latitude, 41° 50′; longitude, 122° 50′; elevation, 2,154 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1887-88	0.15	0.12	0.92	2.58	1.16	1.08	0.61	T.	2.58	2.74	0.15	0.17	[illegible]
1888-89	.32	0	2.57	2.94	.60	.10	2.07	0.43	2.34	0	0	0	[illegible]
1889-90	0	1.95	2.93	2.92	6.00	9.91	.70	.20	.44	.60	.85	.40	[illegible]
1890-91	0	0	0	1.90	.35	2.99	.67	.90	2.40	1.60	.35	[illegible]	[illegible]
1891-92	.55	.65	.70	4.55	.70	.35	1.40	1.50	.50	.60	0	[illegible]	[illegible]
1892-93	.45	.68	2.65	3.98	1.05	1.15	.30	1.50	1.20	T.	.95	0	[illegible]
1893-94	.80	1.60	4.17	3.33	3.20	.70	1.50	0	3.78	1.12	0	0	[illegible]
1894-95	0	1.30	.70	2.30	2.40	.20	2.69	.20	1.20	1.50	.60	.60	[illegible]
1895-96	.55	0	.60	2.95	6.30	.90	2.47	2.00	1.80	0	.80	.55	[illegible]
1896-97	.58	2.02	6.04	5.85	.85	2.10	.80	.40	0	0	0	0	[illegible]
1897-98	0	.60	4.48	3.18	2.95	.10	0	0	.81	0	0	0	[illegible]
1898-99	.28	1.45	3.02	.77	2.17	.63	3.90	0	.10	.10	0	T.	[illegible]
1899-1900	0	1.27	4.66	2.80	3.24	.02	6.10	.57	.46	.55	0	0	[illegible]
1900-1901	0	3.81	3.96	3.13	3.60	2.13	.10	0	.13	0	0	[illegible]	[illegible]
1901-2	1.10	.70	1.17	.93	0	4.96	.55	1.11	1.27	.51	T.	.a	[illegible]
15-year mean													[illegible]

Record of precipitation at Montague, Siskiyou County.

[Latitude, 41° 44′; longitude, 122° 31′; elevation, 2,542 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1888-89	0.61	0.16	0.98	0.30	0.50	0.04	1.78	0.55	1.70	0.60	0	0	[illegible]
1889-90	0	3.20	1.60	3.74	3.70	6.05	3.60	.33	.82	1.15	0	0.35	[illegible]
1890-91	.90	0	0	1.40	.70	2.33	.75	.45	1.74	1.25	.45	0	[illegible]
1891-92	.15	.20	.35	1.83	.10	T.	.75	.40	1.40	0	.35	0	[illegible]
1892-93	0	0	1.25	2.21	.51	1.88	.87	1.75	.44	0	0	0	[illegible]
1893-94	.72	.44	3.05	2.34	2.72	2.13	2.28	.05	2.50	1.04	0	0	[illegible]
1894-95	0	1.00	.54	1.75	2.25	.55	.40	0	.81	0	T.	0	[illegible]
1895-96	.44	0	.56	1.58	3.40	.40	1.49	.81	.96	0	0	.40	[illegible]
1896-97	0	0	2.25	1.43	1.49	2.66	1.35	0	0	1.11	0	0	[illegible]
1897-98	0	0	.76	1.63	.30	1.63	.10	0	.80	0	0	0	[illegible]
1898-99	0	.16	2.18	.20	.72	.22	1.50	.20	.60	.53	0	[illegible]	[illegible]
1899-1900	0	.90	3.15	2.95									[illegible]
11-year mean													[illegible]

[a] Year incomplete.

Record of precipitation at Scott Valley, Siskiyou County.

[Latitude, 41° 45′; longitude, 123° 02′; elevation, 2,570 feet. Authority, Isaac Titcomb.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
58–59	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.50	[a]0.50
59–60	0.87	1.00	4.33	0.75	2.59	1.25	4.12	0.75	2.00	0.50	1.62	.24	20.02
60–61	.49	2.22	2.00	5.74	1.12	2.50	2.50	3.00	.54	.30	0	0	20.41
61–62	0	.51	11.56	10.63	9.29	3.75	1.32	2.00	1.00	.80	.10	0	40.96
62–63	.02	.15	.12	1.90	4.75	1.75	2.45	2.00	.40	1.93	.25	.09	15.81
63–64	.40	.25	1.85	6.17	2.07	.43	.82	2.70	.51	.31	0	.63	16.14
64–65	.04	.31	6.00	12.75	1.87	2.40	1.90	.32	.05	.75	.35	.02	26.16
65–66	1.15	1.33	9.79	1.21	6.59	3.50	9.20	.02	1.72	.62	.50	.47	36.10
66–67	0	.08	2.51	11.75	9.12	2.02	.64	1.34	.41	.04	0	.26	28.17
67–68	.40	.88	1.75	9.68	3.06	1.50	3.70	1.14	.18	1.06	0	0	23.35
68–69	.06	.50	.77	2.80	5.76	1.13	1.32	3.61	1.52	.69	.13	0	18.29
69–70	1.00	.01	3.04	3.56	5.00	2.91	1.73	1.37	1.12	.13	0	0	19.87
70–71	.01	.02	1.00	3.50	1.86	2.47	1.62	2.27	.55	.26	.35	0	13.91
71–72	.37	.05	1.62	7.68	4.18	6.94	1.40	.34	.25	.03	.01	.01	22.88
72–73	.41	.16	2.67	3.38	1.33	3.00	1.05	1.50	.27	.03	.03	.05	13.88
73–74	.37	.94	1.71	4.49	6.38	1.80	3.65	1.55	.71	.13	.01	.09	21.83
74–75	0	1.55	4.33	.43	3.13	.17	1.79	.35	.75	.12	.38	.05	13.05
75–76	0	4.45	7.31	7.33	2.26	3.33	3.94	.71	1.19	.18	.34	1.50	32.54
76–77	1.02	3.75	.54	.01	1.71	4.23	3.10	1.23	1.48	.71	.12	.02	17.92
77–78	.01	.45	.67	1.62	9.72	6.53	3.74	.27	.20	.12	.01	.06	23.40
78–79	.36	2.81	2.16	1.14	3.25	3.54	8.39	2.66	1.40	.27	.38	.47	26.83
79–80	.11	.81	4.64	4.58	10.62	2.32	2.65	5.39	1.32	.02	.37	.07	32.90
80–81	0	.18	.32	6.76	13.95	6.53	.79	1.19	.17	1.04	.54	.04	31.51
81–82	.76	3.53	2.40	4.60	4.48	5.69	2.22	2.45	1.29	.08	2.49	0	29.99
82–83	1.44	2.86	2.72	3.75	2.58	1.51	1.11	3.25	2.65	0	.40	.63	22.90
83–84	.66	2.41	1.11	4.75	4.28	3.14	3.45	3.06	1.65	.87	1.62	.01	27.01
84–85	.60	1.04	.16	8.18	2.50	3.49	.11	1.98	1.40	1.40	1.16	.01	22.03
85–86	.83	.53	10.24	3.26	7.22	1.32	1.32	3.23	1.77	.03	2.13	.85	32.73
86–87	0	1.85	.78	6.67	5.18	4.96	1.07	2.63	.94	.36	.37	.18	24.99
87–88	.36	.09	1.75	5.88	6.18	1.77	2.43	.18	1.80	4.21	.60	.11	25.36
88–89	.58	.40	1.94	1.59	2.71	.50	4.35	2.56	4.71	.19	1.11	0	20.64
89–90	0	3.95	3.37	12.84	21.81	11.10	.....	.....	.....	.....	.....	.....	[a]53.07
10-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.05

[a] Year incomplete.

Record of precipitation at Sissons, Siskiyou County.

[Latitude, 41° 27′; longitude, 122° 25′; elevation, 3,555 feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1881–82	0.99	2.53	3.34	8.54	6.35	2.90	1.74	1.65	0.60	0	0	0	28.64
1882–83	1.19	4.44	3.20	1.65	.99	1.10	10.15	6.15	0	0	0	0	28.87
1888–89	.40	3.70	2.17	2.91	.60	.40	16.27	.63	2.40	0.23	0	0	29.71
1889–90	0	16.45	5.80	16.13	5.69	9.33	5.30	2.98	2.75	.44	0	0	64.87
1890–91	1.20	.13	0	3.18	.40	7.17	.61	3.64	2.65	.44	0.60	0	20.02
1891–92	.32	.30	.35	11.20	2.34	.66	4.19	5.38	3.74	.39	0	0	28.87
1892–93	1.71	1.06	8.75	9.57	3.10	2.80	2.77	2.60	2.66	.03	0	0	35.02
1893–94	.68	.61	4.25	2.87	10.72	2.60	3.45	.70	2.85	2.25	0	0	30.98
1894–95	.99	3.65	1.70	11.13	9.12	1.24	3.84	1.27	2.05	0	.55	0	35.54
1895–96	4.65	3.70	.70	4.31	21.09	.21	4.16	3.55	3.02	0	.13	0.81	45.83
1896–97	.....	.....	.....	.....	2.59	4.86	.43	.53	0	.15	0	0	[a]8.56
1897–98	0	2.31	2.62	3.72	0	10.45	4.70	1.05	6.13	1.03	.13	0	32.14
1898–99	0	0	1.70	2.10	5.55	1.03	2.98	.23	1.32	.89	0	1.32	17.12
1899–1900	0	4.01	10.83	5.67	8.64	1.04	9.92	3.49	2.05	1.24	0	.16	47.05
1900–1901	.67	10.76	4.52	3.80	11.97	8.99	.62	2.73	.95	0	26	.36	45.63
1901–2	2.08	1.93	6.58	2.77	1.83	21.73	4.14	5.08	2.87	T.	.38	4.16	53.55
15-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	36.26

[a] Year incomplete.

Record of precipitation at Walla Walla Creek, Siskiyou County.

[Latitude, 41° 42′; longitude, 122° 55; elevation, 3,000 feet. Authority, S. Titcomb.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	T...
1888–89	.....	.....	.....	.....	1.86	0.25	3.85	1.66	3.46	0.19	1.11	0	...
1889–90	0	3.95	3.37	8.09	11.86	9.10	4.93	1.24	1.29	.28	0	0.5	...
1890–91	1.84	.10	.19	3.85	1.70	6.13	2.03	1.11	3.28	.99	.22	.4	...
1891–92	1.18	.39	1.10	12.40	2.38	.47	2.39	2.94	1.29	.76	.35	0	...
1892–93	.82	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...
3-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...

[a] Year incomplete.

Record of precipitation at Yreka, Siskiyou County.

[Latitude, 41° 45′; longitude, 122° 32′; elevation, 2,635 feet. Authority, Dr. L. Antevrin.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	T...
1871–72	0.33	1.24	1.98	2.61	3.83	1.91	1.67	2.04	0.44	0	0.14	0	...
1872–73	.25	1.55	1.43	3.92	1.28	1.77	.40	.90	.60	0	0	0	...
1873–74	.44	.55	1.17	2.20	3.78	1.62	1.49	.74	.34	0.44	0	0	...
1874–75	0	1.29	2.16	0	4.35	.19	1.49	.17	.51	.30	.07	0	...
1875–76	0	3.34	5.29	6.07	2.00	1.93	2.07	.42	.65	.20	.32	0.19	...
1876–77	.90	3.05	.43	.26	1.20	3.24	1.48	.74	1.56	.65	.18	0	...
1877–78	.90	.20	3.84	.95	6.12	3.91	2.80	.37	.56	0	.73	0	...
1878–79	.25	.45	1.15	.45	1.53	1.41	3.96	1.56	1.42	.39	.22	.15	...
1879–80	.25	.77	2.32	7.23	2.43	.61	1.20	2.23	.41	.15	0	0	...
1880–81	0	.13	.10	2.42	11.78	2.58	.19	.48	0	1.23	0	0	...
1881–82	.30	3.24	.68	1.60	1.81	1.96	.42	1.20	1.02	0	0	0	...
1882–83	.90	1.88	1.89	2.09	1.38	.47	.53	1.26	1.76	0	.33	.5	...
1883–84	.33	1.35	.66	2.95	2.10	1.20	2.34	1.41	1.40	1.78	1.33	.51	...
1884–85	.33	0	.79	6.19	1.16	2.94	0	1.12	3.65	1.66	.58	0	...
1885–86	.49	.29	2.98	2.10	4.03	.91	.74	1.78	1.05	0	1.51	.15	...
1886–87	0	1.69	.30	4.14	3.21	3.01	.41	2.35	1.42	.84	1.28	.31	...
1887–88	.21	0	1.04	1.99	4.90	1.19	1.16	.11	1.12	2.39	.24	0	...
1888–89	.87	.34	1.13	0	1.30	1.30	2.12	1.32	1.70	.10	.94	0	...
1889–90	0	3.53	2.23	4.08	3.59	8.89	3.09	.....	.....	.....	.....	.....	...
1890–91	.....	.....	.....	.....	.....	3.59	1.15	.93	1.48	1.36	.41	0	...
1891–92	.82	.43	2.20	3.92	1.65	.15	1.02	1.02	1.20	.87	.31	0	...
1892–93	.61	.05	3.37	3.64	1.20	2.53	1.53	2.10	.87	.32	.58	.0	...
1893–94	1.12	.54	7.83	2.11	7.59	3.22	3.32	.10	3.31	.70	.77	.41	...
1894–95	.01	1.60	.57	5.40	5.30	1.03	2.26	.81	1.59	0	.43	.6	...
1895–96	.82	T.	.86	4.31	7.37	1.08	1.89	2.28	2.75	.81	.73	1.01	...
1896–97	.52	.89	5.02	3.70	.42	3.89	2.18	.39	.58	1.51	0	.20	...
1897–98	.12	.68	2.94	3.76	.83	1.44	.42	.48	2.08	.10	.02	.05	...
1898–99	.14	.51	2.74	1.04	2.75	1.95	1.77	.21	.62	.61	.08	.12	...
1899–1900	.07	2.34	5.00	3.80	1.35	2.13	1.12	.42	.37	1.36	0	1.35	...
1900–1901	.43	3.06	2.00	3.23	8.12	2.86	.98	.40	.52	0	.01	.95	...
1901–2	1.24	1.28	1.81	3.09	.39	6.68	1.53	1.21	1.08	.03	.19	.0	...
29-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...

[a] Year incomplete.

Record of precipitation at Weaverville, Trinity County.

[Latitude, 40° 46′; longitude, 123° 25′; elevation, 2,162 feet. Authority, George E. Noonan.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
869–70	1.06	1.03	8.01	6.15	10.11	9.64	2.05	1.06	0.22	0	0	0	39.33
870–71	.64	1.39	6.41	9.43	8.16	11.19	3.02	1.73	1.03	0.14	0	0	43.14
871–72	.29	.40	11.50	3.52	19.62	15.09	3.11	2.43	.84	.17	0	0.25	57.22
872–73	.35	.78	3.01	6.82	6.51	4.29	2.78	.50	.27	0	0	0	24.81
873–74	1.80	4.39	4.02	9.57	15.40	4.41	3.12	3.58	2.67	.70	0	0	49.66
874–75	0	1.57	10.30	1.32	6.59	.46	2.14	.19	1.22	.93	0	0	24.72
875–76	0	2.82	15.39	11.94	9.69	9.49	8.23	2.79	1.63	.15	0.47	0	62.60
876–77	.67	7.38	1.50	.29	6.27	6.24	4.52	2.26	1.62	1.72	.02	.21	32.70
877–78	0	1.83	8.72	6.50	19.83	16.20	8.53	2.42	1.07	.07	.02	.03	65.22
878–79	1.28	1.80	3.58	4.91	2.02	6.48	12.84	4.05	4.02	.68	.02	.03	41.71
879–80	.03	2.08	8.09	13.20	6.64	2.59	4.72	10.78	1.46	.23	.38	.36	50.56
880–81	0	.55	1.49	14.14	18.61	11.05	1.21	3.13	1.15	.99	0	0	52.32
881–82	.93	3.77	2.58	8.00	4.19	6.90	3.62	2.44	1.29	0	0	0	33.72
882–83	1.38	8.36	.78	5.05	4.46	1.50	3.24	5.00	3.72	0	0	0	33.49
883–84	.88	2.45	1.50	4.97	8.81	3.56	5.10	6.29	1.60	2.93	.13	0	38.22
884–85	.44	.11	16.56	6.78	3.68	3.70	.15	2.78	.51	1.41	0	0	36.12
885–86	.....	.....	.....	.....	8.71	.80	2.94	.....	.....	.....	.....	.....	[a]12.45
6-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	42.85
893–94	.....	.....	.....	.....	11.47	5.02	4.60	.....	2.22	.....	.....	.....	[a]23.31

[a] Year incomplete.

Record of precipitation at Milo, Tulare County.

[Latitude, 36° 15′; longitude, 118° 50′; elevation, 3,200 feet. Authority, Henry Murphy.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
900–1901	.....	.....	.....	.....	5.74	4.06	1.33	2.45	3.36	0	0	0	[a]16.94
1901–2	0.51	1.80	1.47	0.27	1.00	6.47	4.33	1.69	.54	0	T.	0	18.08

[a] Year incomplete.

Record of precipitation at Mountain Home, Tulare County.

[Latitude, 36° 10′; longitude, 118° 48′; elevation, 6,680 feet. Authority, Fred Moller and N. T. Bailey.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1895–96	.....	.....	.....	.....	14.36	0.84	8.93	8.63	1.30	2.70	0.65	0.50	[a]37.91
1896–97	.....	0.60	0.40	1.95	5.70	7.45	6.07	.40	1.85	.20	.25	0	[a]24.87
1897–98	0.10	2.45	.73	3.31	.....	.....	.....	.....	.....	.....	.....	.....	[a]6.59

[a] Year incomplete.

Record of precipitation at Porterville, Tulare County.

[Latitude, 36°; longitude, 119°; elevation, 461 feet. Authority, Southern Pacific Company, Murphy, agent.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Tot.
1892-93	.....	.....	0.54	2.43	0.83	1.85	3.68	0.27	0	0	0	0	[illegible]
1893-94	0	0	.07	.61	1.52	.83	.70	.32	0.42	1.09	0	0	[illegible]
1894-95	0.43	.15	.04	3.13	3.82	1.54	1.10	.41	.35	0	0	0	[illegible]
1895-96	0	.23	1.71	.51	1.61	T.	.67	.82	.13	0	.09	0	[illegible]
1896-97	0	.65	.94	.93	1.96	2.46	2.00	.30	.42	0	0	0	[illegible]
1897-98	0	1.19	.50	.89	.75	1.55	.68	0	.55	0	0	0	[illegible]
1898-99	2.10	0	.27	.35	1.01	.17	2.92	.19	.10	.85	0	T.	[illegible]
1899-1900	0	1.08	.88	.91	.97	.16	.89	1.94	2.41	0	T.	0	[illegible]
1900-1901	T.	.04	3.44	.30	2.74	1.78	.30	2.19	1.97	0	0	T.	[illegible]
1901-2	.41	.45	.71	T.	.84	2.96	2.28	1.53	.15	0	T.	0	[illegible]
10-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]

[a] Year incomplete.

Record of precipitation at Crockers (Sequoia post-office), Tuolumne County.

[Latitude, 37° 50′; longitude, 119° 53′; elevation, 4,452 feet. Authority, H. R. Crocker.

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Tot.
1895-96	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]	[illegible]
1896-97	0.14	2.30	9.18	5.41	6.56	15.97	21.80	1.33	0	0.75	0	0	[illegible]
1897-98	.45	6.09	2.70	3.80	2.60	7.15	3.74	1.10	3.74	0	0	0	[illegible]
1898-99	1.58	1.87	1.85	2.12	11.72	1.80	18.09	1.60	.15	1.65	0	0	[illegible]
1899-1900	0	11.50	7.45	12.18	5.98	1.18	[b] 4.28	3.56	1.80	.47	0	0	[illegible]
1900-1901	.62	9.71	17.43	1.39	16.99	15.71	3.03	6.35	3.81	0	0	0	[illegible]
1901-2	3.28	4.59	3.90	2.50	2.33	15.03	8.55	6.54	1.80	0	0	[illegible]	[illegible]
6-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]

[a] Year incomplete. [b] March, 1900, violent hailstorm.

Record of precipitation at Dering Creek (30 miles east of Sonora), Tuolumne County.

[Latitude, 38° 00′; longitude, 119° 40′; elevation, 7,000 feet.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Tot.
1898-99	.....	1.85	2.88	2.78	9.95	2.77	17.08	0.12	.....	.....	.....	.....	[illegible]

[a] Year incomplete.

Record of precipitation at Second Garotte, Tuolumne County.

[Latitude, 37° 39′ N.; longitude, 120° 24′; elevation, 2,714 feet. Authority, J. P. Chamberlain.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1882–83	.....	.....	.....	.....	1.25	4.52	8.27	2.00	3.50	0	0	0	[a]19.54
1883–84	0.63	0.75	0.75	1.00	8.00	14.00	16.00	9.00	1.00	1.48	0	0	52.61
1884–85	0	2.00	0	18.50	4.00	0	0	1.50	0	3.50	0	0	29.50
1885–86	.25	0	18.00	5.00	10.00	1.00	5.50	6.25	.50	0	0	0	46.50
1886–87	0	1.00	1.75	2.75	1.00	13.75	1.25	5.50	0	0	0	0	27.00
1887–88	1.00	0	2.00	7.00	7.75	1.50	3.00	1.25	1.25	.25	0	0	25.00
1888–89	.50	0	5.00	4.25	.50	1.00	9.75	.50	5.75	0	0	0	27.25
1889–90	0	6.50	5.75	22.00	15.00	6.75	7.25	2.00	1.75	0	0	.25	67.25
1890–91	2.27	0	0	9.00	2.00	14.00	5.00	3.50	.25	0	0	0	36.02
1891–92	0	.25	0	11.25	2.25	3.25	7.00	2.00	6.25	0	0	0	32.25
1892–93	.25	1.25	10.00	8.75	6.00	7.25	11.25	2.50	0	0	0	0	47.25
1893–94	.50	.25	3.00	4.00	10.50	10.75	2.25	1.25	3.75	1.00	0	0	37.25
1894–95	2.00	2.00	.50	18.00	13.00	4.25	8.75	2.00	1.50	0	0	0	52.00
1895–96	0	0	1.75	2.75	12.00	0	5.55	7.25	.25	0	0	2.50	32.05
1896–97	0	3.00	6.00	4.50	4.00	10.75	9.01	.53	T.	T.	0	0	37.79
1897–98	T.	2.75	1.00	2.50	2.75	6.00	2.50	.25	2.50	0	0	0	20.25
1898–99	2.00	1.50	1.50	1.00	6.76	1.00	14.00	.53	1.00	T.	T.	0	29.29
1899–1900	0	6.72	6.75	6.00	5.25	1.25	3.75	4.00	1.50	0	0	0	35.22
1900–1901	.25	5.00	14.00	1.50	11.00	17.75	1.25	4.00	1.00	0	0	0	55.75
1901–2	2.25	2.25	2.00	2.00	1.25	11.75	4.75	3.25	1.00	.....	.....	.....	[a]30.50
18-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	38.35

[a] Year incomplete.

Record of precipitation at Sonora, Tuolumne County.

[Latitude, 37° 58′; longitude, 120° 22′; elevation, 1,900 feet. Authority, John Shaw.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1887–88	0.64	0	0.70	5.76	7.92	1.32	3.91	0.25	1.02	0.23	0	0	21.75
1888–89	.54	0	4.45	5.04	.88	1.75	7.22	.96	4.77	.05	0	0	25.66
1889–90	0	6.83	7.04	18.25	13.59	9.27	7.40	2.66	2.35	0	0	0	67.39
1890–91	1.69	.09	.10	10.23	1.74	9.60	3.79	3.77	.60	.68	0	0	32.29
1891–92	.36	.37	.08	9.10	1.69	4.20	6.40	2.93	5.18	.09	0	0	30.40
1892–93	.38	1.88	10.28	6.52	4.88	5.93	11.11	2.51	.27	0	0	T.	43.76
1893–94	.53	.35	8.39	3.87	8.76	11.46	2.39	1.32	3.96	1.48	T.	0.02	37.53
1894–95	1.21	4.74	0	14.53	11.19	4.62	4.01	3.25	2.40	0	0	0	45.95
1895–96	.61	.21	.75	2.51	10.80	.49	5.00	8.65	1.14	0	0.40	.61	31.17
1896–97	.25	2.85	6.74	3.97	3.31	11.89	8.37	.29	.25	.31	0	0	38.23
1897–98	.10	3.35	2.15	2.53	1.71	5.79	1.96	.60	2.70	.15	0	0	21.04
1898–99	.87	.84	1.51	2.64	6.99	.42	14.03	1.08	2.18	2.17	0	.08	32.81
1899–1900	0	6.90	7.02	5.38	3.20	1.37	2.75	4.28	2.01	.20	0	.03	33.14
1900–1901	.14	5.10	10.29	2.05	9.04	12.89	1.26	4.73	1.18	.07	0	.04	46.79
1901–2	2.42	1.81	3.15	2.40	1.35	7.86	5.53	2.45	1.44	0	0	.01	28.42
15-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	35.76

Record of precipitation at Frazier mine, Ventura County.

[Latitude, 34° 45′; longitude, 118° 00′; elevation, 8,000 feet. Authority, Harry C. Porter.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1894–95	.....	.....	.....	.....	.....	.....	.....	.....	0.40	0	0	0	[illegible]
1895–96	0	0.30	0.90	0.68	2.94	0	3.12	2.22	1.03	0	0.15	3.73	[illegible]
1896–97	0	1.47	.73	4.07	7.37	6.33	4.05	.16	.28	0	.02	.45	[illegible]
1897–98	0.33	1.00	T.	1.35	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]
1898–99	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.60	0	.....	[illegible]
2-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]

[a] Year incomplete.

Record of precipitation at Mutah Flat, Ventura County.

[Latitude, 34° 38′; longitude, 119° 08′; elevation, 4,850 feet. Authority, Burt Snedden Griffin.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1893–94	0.22	1.70	0	4.10	0.54	1.41	0.30	0.13	0.79	0	0	0	[illegible]
1894–95	0	.85	0	7.38	9.80	.78	2.95	0	0	0	0	0	[illegible]
1895–96	0	.65	1.60	1.10	4.58	0	4.79	3.50	.52	0	0.30	0	[illegible]
1896–97	0	1.75	1.50	2.80	9.10	3.50	3.59	0	0	0	.30	0	[illegible]
1897–98	0	1.75	0	.15	.60	1.00	.90	0	.60	0.40	0	0	[illegible]
1898–99	1.80	0	0	.30	2.25	0	2.50	.50	0	0	0	0	[illegible]
1899–1900	0	2.00	1.30	2.25	2.80	0	1.95	.40	1.80	0	0	0	[illegible]
1900–1901	0	0	5.10	0	7.00	4.60	.25	1.10	.58	0	0	0	[illegible]
1901–2	0	2.85	.65	0	.75	3.23	2.80	1.41	0	0	0	0	[illegible]
9-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]

Record of precipitation at Nordhoff, Ventura County.

[Latitude, 34° 27′; longitude, 119° 08′; elevation, 1,200 feet. Authority, R. Robinson, J. W. Wood and H. Lathrop.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1886–87	0	0.36	1.10	0.78	0.22	16.81	0.44	1.88	0.18	.....	.....	.....	[illegible]
1887–88	.....	.....	1.63	5.29	7.46	1.28	5.47	.54	.26	.....	.....	.....	[illegible]
1888–89	.....	0	5.96	7.22	0	.....	.....	.....	.....	.....	.....	.....	[illegible]
1890–91	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	0	[illegible]
1891–92	0.25	0	T.	2.58	.67	2.75	3.68	.47	1.39	0	0	0	[illegible]
1892–93	0	1.08	1.35	8.75	5.80	3.64	7.75	.45	T.	0	0	0	[illegible]
1893–94	0	.61	T.	3.45	.68	.74	.29	.19	.97	0	0.08	0	[illegible]
1894–95	.08	.45	0	6.39	8.61	.46	3.66	.39	0	0	0	0	[illegible]
1895–96	0	.10	1.09	0	5.78	0	3.42	1.72	0	0	.22	T.	[illegible]
1896–97	0	1.38	1.08	3.00	4.11	7.16	2.91	0	0	0	0	0	[illegible]
1897–98	.....	.....	.....	.....	.....	.....	.43	0	.....	0	0	0	[illegible]
1898–99	0	.13	.....	.....	3.98	.....	2.71	.27	0	0	.....	0	[illegible]
1899–1900	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]
1900–1901	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]
1901–2	.25	4.38	1.25	0	1.37	5.50	4.13	2.50	0	0	0	0	[illegible]
9-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	[illegible]

[a] Year incomplete.

Record of precipitation at Smith's ranch, Ventura County.

Latitude, 34° 44′; longitude, 118° 47′; elevation, 4,000 feet. Authority, William Smith, Gorman Station.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
898–99	.....	.....	.....	.....	0.82	1.00	1.45	0	0	0	0	0	[a]3.27
899–1900	0	0.95	0.65	0.35	1.20	0	1.12	0.12	0.75	0	0	0	5.14
900–1901	0.15	0	3.10	0	2.35	2.25	.10	.32	.45	0	0	0.95	9.67
901–2	.10	.25	.20	0	.....	.....	.....	.....	.....	.....	.....	.....	[a].55
4-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7.41

[a] Year incomplete.

Record of precipitation at Snedden's ranch, Ventura County.

[Latitude, 34° 41′; longitude, 119° 03′; elevation, 4,900 feet. Authority, Burt Snedden Griffin.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1892–93	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.14	0.02	[a]0.16
1893–94	0.03	0.72	0	4.45	1.31	0.65	0.45	0.16	0.75	0	0	1.15	9.67
1894–95	.75	0	0	6.99	6.31	.49	1.50	.11	0	0	0	0	16.15
1895–96	0	.16	0.91	.55	3.47	0	5.02	3.79	.57	0	.25	T.	14.72
1896–97	.33	1.10	1.35	2.40	8.30	2.92	2.71	.02	0	0	.25	.20	19.58
1897–98	.14	.70	0	.05	.60	.41	.65	0	.54	0.35	0	0	3.44
1898–99	1.75	0	0	.30	2.65	0	1.50	.50	0	0	0	0	6.70
1899–1900	0	1.50	.47	.27	1.40	T.	1.45	.50	1.40	0	0	0	6.99
1900–1901	0	0	4.52	0	3.70	3.80	.10	1.10	.47	0	0	0	13.69
1901–2	0	1.75	1.75	0	.56	2.95	1.85	.50	0	0	0	0	9.36
9-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11.14

[a] Year incomplete.

Record of precipitation at Upper Lake, Ventura County.

[Latitude, 34° 41′; longitude, 119° 03′; elevation, 4,900 feet. Authority, U. S. Weather Bureau.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb	Mar.	Apr.	May.	June.	July.	Aug.	Total.
1890–91	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	[a]0
1891–92	0.95	0.62	0.71	7.35	3.93	2.50	3.18	2.84	3.71	0.49	0	0	26.28
1892–93	T.	1.17	3.50	5.30	4.08	5.19	5.47	2.37	1.04	0	T.	0	28.12
1893–94	.85	.47	4.83	2.82	10.43	6.21	1.80	1.46	1.02	1.12	0	T.	31.01
1894–95	.53	2.05	1.13	11.62	14.92	4.15	3.20	1.41	1.39	0	0.05	T.	40.45
1895–96	.46	T.	3.50	5.30	11.18	.80	2.39	6.01	2.07	0	T.	0.87	32.58
1896–97	.42	1.04	5.07	6.47	3.45	6.35	4.58	.42	.22	.97	.05	0	29.04
1897–98	.08	1.67	2.38	2.61	.93	4.57	.36	.43	1.90	.58	0	T.	15.51
1898–99	.60	1.01	1.66	1.34	8.16	.25	5.59	.90	1.00	.05	0	.03	20.59
1899–1900	0	3.49	6.33	9.79	3.98	1.31	3.53	2.13	.81	.35	T.	0	31.72
1900–1901	.03	3.96	5.08	3.63	6.44	4.75	1.06	2.43	.70	0	T.	T.	28.08
1901–2	1.11	1.09	4.35	2.09	1.35	12.82	3.87	2.85	1.60	0	0	.07	31.20
11-year mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	28.60

[a] Year incomplete.

Record of precipitation at Ventura, Ventura County.

[Latitude, 34° 20′; longitude, 119° 20′; elevation, 50 feet. Authority, Mr. Saxby.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total
1873–74	0	0	0.50	4.50	3.75	4.75	1.00	0	0.50	0	0	0	[illegible]
1874–75	0	0.50	.75	0	13.75	.12	.12	0	0	0	0	0	[illegible]
1875–76	0	0	5.00	.25	7.75	5.75	2.25	0	0	0	0	0	[illegible]
1876–77	0	0	0	0	3.60	0	.50	0.37	.75	0	0	0	[illegible]
1877–78	0	0	3.65	0	4.10	8.51	1.45	2.26	.25	0	0	0	[illegible]
1878–79	0	.34	0	4.07	4.67	1.09	.23	2.14	.25	0	0	0	[illegible]
1879–80	0	.57	1.91	4.98	1.41	7.63	1.95	3.61	0	0	0	0	[illegible]
1880–81	0	.25	.84	8.19	2.47	.18	1.53	.45	0	0	0	0	[illegible]
1881–82	0.06	1.98	.25	.81	.60	2.79	4.20	1.23	.06	0	0	0	[illegible]
1882–83	0	.31	.71	.10	3.48	2.35	1.95	.18	2.41	0.02	0	0	[illegible]
1883–84	0	1.00	0	4.46	7.38	9.96	9.44	2.06	.13	1.70	0	0	[illegible]
1884–85	0	.38	.84	4.95	1.25	.23	1.58	.23	0	0	0	0	[illegible]
1885–86	0	.03	.33	1.03	6.16	.34	2.27	1.97	.09	0	0	0	[illegible]
1886–87	0	.02	.94	.64	.20	11.08	.39	1.37	.11	0	0	0	[illegible]
1887–88	.06	.02	2.71	2.86	8.19	1.62	4.51	.34	0	0	0	0	[illegible]
1888–89	0	.04	4.47	4.39	.20	1.46	5.64	0	.65	0	0	0	[illegible]
1889–90	0	4.45	2.85	11.04	5.01	1.85	.45	0	0	0	0	0.08	[illegible]
1890–91	.84	0	.40	2.69	.45	7.12	3.10	.60	.16	0	0	0	[illegible]
1891–92	.98	0	0	1.75	1.05	4.54	.29	0	0	0	0	0	[illegible]
1892–93	0	.70	2.15	5.80	3.17	3.02	7.88	.42	.40	0	0	0	[illegible]
1893–94	0	.85	.25	2.04	.81	.50	.27	.17	.50	0	0	0	[illegible]
1894–95	.95	.10	0	3.13	5.25	1.00	3.17	.47	.86	.07	0	0	[illegible]
22-year mean													[illegible]

Record of precipitation at Rumsey, Yolo County.

[Latitude, 38° 51′; longitude, 122° 14′; elevation, — feet. Authority, Pacific Railway System.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total
1888–89	0.80	0	6.55	5.15	0.95	1.35	8.20	1.40	2.45	0.15	0	0	[illegible]
1889–90	0	7.90	4.13	12.07	12.01	4.52	5.32	1.17	1.29	0	0	0	[illegible]
1890–91	.35	0	0	3.91	.87	13.60	1.16	1.92	1.28	0	0	0	[illegible]
1891–92	.85	0	.35	4.98	3.49	2.84	3.02	1.21	2.78	0	0	0	[illegible]
1892–93	0	1.03	10.57	11.37	4.80	5.42	5.77	1.76	.77	0	0	0	[illegible]
5-year mean													[illegible]

Record of precipitation at Colgate, Yuba County.

[Latitude, 39° 22′; longitude, 121° 10′; elevation, 650 feet.[a] Authority, Bay Counties Power Company.]

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Total
1900–1901	0	6.79	7.45	0	6.98	5.07	2.11	0	0.08	0	0	0	[illegible]
1901–2	1.48	3.61	4.39	5.31	1.44	18.22	4.23	4.10	.80	0	0	0	[illegible]
2-year mean													[illegible]

[a] Gage at bottom of canyon 1,000 feet deep.

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Water supply and irrigation papers
no. 81. Lippincott, J. B. California hydrography. 1903.

Reference.

U. S. Dept. of the Interior.

see also

U. S. Geological survey.

Water-Supply and Irrigation Paper No. 82 Series P, Hydrographic Progress Reports, 20

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

REPORT

OF

ROGRESS OF STREAM MEASUREMENTS

FOR

THE CALENDAR YEAR 1902

BY

F. H. NEWELL

PART I.—NORTHERN ATLANTIC COAST AND ST. LAWRENCE RIVER DRAINAGE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1903

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, D. C., February 18, 1903.

SIR: I have the honor to transmit herewith the first number of a ies of four papers descriptive of the results of the hydrographic asurements made during the year 1902. These papers will contain data which heretofore have been published in our Water-Supply pers under the title of Operations at River Stations, and in the port of Progress of Stream Measurements, which report until 1901 de up Part IV of the Annual Report. The data usually found in rt IV of the Annual Report were in 1901 published in Water-Supply per No. 75. These papers present briefly the original data as col- ted by the various resident hydrographers, together with the com- tations and results which have been based upon these facts.

This paper contains the data collected at the stations located in at portion of the Atlantic coast drainage north of and including the mes River Basin. Part II will contain the data for the remainder the stations east of the Mississippi, and Parts III and IV the data r the stations located west of the Mississippi.

Very respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

'ROGRESS REPORT OF STREAM MEASUREMENTS FOR THE CALENDAR YEAR 1902.

PART I.

By F. H. NEWELL.

INTRODUCTION.

The determinations of the water supply of various parts of the nited States have been continued during the year 1902 by the ivision of Hydrography in a manner similar to that of previous ears, slight modifications and improvements having been introduced methods and operations. The work consists in measuring the reams and estimating the water supply, both above and under round. To give full facts concerning the water supply it is necesary not merely to ascertain the quantity, but also in many cases the uality, and especially the possibilities of water storage or conservaon. Water can not be considered as a resource unless it can be had hen needed, and therefore the determination of the practicability of olding the floods until time of drought underlies any statement of ater supply. In a similar way when considering underground waters is not enough to know that there is water beneath the surface, but he facts must be ascertained as to the depth to the water, the rate f movement, if any, and the possibility of bringing the water to the urface at reasonable cost.

The principal operation of the hydrographic surveys, as at present onducted, is that of measuring the waters flowing upon the surface, btaining their fluctuations in quantity, and sometimes in quality, rom month to month and from year to year.

During 1902 the number of stations at which stream measurements ere made was steadily increased. This is largely the result of the onstant demand for the data collected by the Survey. The requests or information have been so great that the supply of publications as become practically exhausted, necessitating the reprinting in ondensed form of the data collected in various localities.

The Survey has received the hearty cooperation of various indiiduals, corporations, and States, as mentioned hereafter. This ooperation has made possible the publication of many valuable ecords which could not otherwise have been obtained.

A brief historical sketch of the stream measurements made by the Geological Survey is published on pages 11 to 15 of Water-Supply Paper No. 75.

The results of the stream measurements made during previous years by the United States Geological Survey can be found in the following Survey publications, which may be consulted at the public libraries in all the large cities:

1893.
1894. } Bulletin No. 131.
1895. Bulletin No. 140.
1896. Water-Supply Paper No. 11; Eighteenth Annual Report, Part IV.
1897. Water-Supply Papers Nos. 15 and 16; Nineteenth Annual Report, Part IV.
1898. Water-Supply Papers Nos. 27 and 28; Twentieth Annual Report, Part IV.
1899. Water-Supply Papers Nos. 35 to 39, inclusive; Twenty-first Annual Report, Part IV.
1900. Water-Supply Papers Nos. 47 to 52, inclusive; Twenty-second Annual Report, Part IV.
1901. Water-Supply Papers Nos. 65, 66, and 75.
1902. Water-Supply Papers Nos. 82 to 85, inclusive.

ACKNOWLEDGMENTS.

Most of the measurements presented in this paper have been obtained through local hydrographers. Acknowledgment is due to each of these persons, and thanks are extended to other persons and corporations who have assisted local hydrographers or have cooperated in any way, either by furnishing records of the height of water or by assisting in transportation.

The following list, arranged geographically by States, gives the names of the resident hydrographers and others who have assisted in furnishing and preparing the data contained in this report:

Maine.—Resident hydrographer, N. C. Grover, professor of civil engineering, University of Maine, Orono, Me., assisted by F. E. Pressey. Acknowledgment should also be made to the Bangor and Aroostook Railroad and to the Somerset Railroad, for annual passes issued to N. C. Grover; to the Maine Central Railroad, for a pass between April 1 and October 1; to the Portland and Rumford Falls Railroad, for trip passes issued when desired. Thanks are due the following individuals and corporations for data furnished and assistance rendered: A. C. Mixer, engineer of the Rumford Falls Power Company, for records of the flow of the Androscoggin at Rumford Falls; Messrs. S. D. Warren & Co., of Westbrook, Me., for records of the flow of the Presumpscot; Alexander H. Twombly, engineer of the Forest Paper Company, of Yarmouthville, Me., for records of the flow of the Cobbosseecontee; Hollingsworth and Whitney Company, of Winslow, Me., for records from which the flow of the Kennebec at Waterville has been computed; and H. S. Ferguson, engineer of the Great Northern Paper Company, of Millinocket, Me., for records from which the flow of the Penobscot at Millinocket has been computed.

New Hampshire.—C. A. Holden, professor of civil engineering, Thayer School, Hanover, N. H., for measurements of the Connecticut River at Orford, N. H.

Massachusetts.—Frederic P. Stearns, chief engineer, and C. W. Sherman, division engineer of the Metropolitan Water Board of Boston, for records of the flow

Sudbury and Nashua rivers and of Lake Cochituate; R. A. Hale, principal assistant engineer, Essex County, for records of the flow of Merrimac River at Lawrence, Mass., and Capt. Harry Taylor, U. S. Army, Boston, Mass.

Connecticut.—Edwin D. Graves, chief engineer Connecticut River Bridge and Highway District, for the gage heights of Connecticut River near Hartford, Conn., and Greenwich Water Company of Greenwich, Conn.

Rhode Island.—John E. Hill, professor of civil engineering at Brown University, Providence, R. I., for records of the flow of Blackstone River and canal at Berkeley, R. I.

New York.—Resident hydrographer, Robt. E. Horton, assisted by C. C. Covert and F. H. Tillinghast. Special acknowledgment is made to Edward A. Bond, state engineer and surveyor, for his hearty cooperation and assistance in the work. Thanks are due the following persons for data furnished and assistance rendered: Wm. S. Bacot, engineer and general manager of the Consolidated Water Company, Utica, N. Y.; Stephen E. Babcock, C. E., Little Falls, N. Y.; City Water Department, Oswego, N. Y.; Frank E. Hinds, C. E., Watertown, N. Y.; Wm. G. Raymond, C. E., Troy, N. Y.; Hannawa Falls Water Power Company, Hannawa Falls, N. Y.; Utica Gas and Electric Company, Utica, N. Y.; International Paper Company, Fort Edwards, N. Y.; Duncan Company, Mechanicville, N. Y.; Honk Fall Power Company, Ellensville, N. Y.; Fishkill and Matteawan Water Company, Fishkill on the Hudson, N. Y.; Binghamton Railway Company, Binghamton, N. Y.; S. E. Moore, C. E., Binghamton, N. Y.; O. C. Reed, C. E., Fulton, N. Y.; and E. A. Fisher, C. E., Rochester, N. Y.

New Jersey.—Resident hydrographers, G. B. Hollister and E. G. Paul.

Pennsylvania.—Resident hydrographer, E. G. Paul. Thanks are due to the following persons, who have rendered assistance and furnished data: Mansfield Merriman, professor of civil engineering at Lehigh University, South Bethlehem, Pa.; E. Mather, president of the Harrisburg water commission, Harrisburg, Pa.; John E. Codman, hydrographer for the city water board, Philadelphia, Pa.; and J. A. Snyder, city engineer, Williamsport, Pa.

Maryland.—Resident hydrographer, E. G. Paul.

Virginia and West Virginia.—Resident hydrographers, E. G. Paul and D. C. Humphreys, professor of civil engineering at Washington and Lee University, Lexington, Va.

Acknowledgments are also due to John C. Hoyt, George L. Warner, and H. G. Stokes for computations on and the arrangement of the data in this report; also to H. A. Pressey for assistance in both field and office.

WATER POWERS IN MAINE.

The rivers of the State of Maine furnish some of the best water-power sites in the United States. The large rivers have their sources in general at high elevations among the mountains and hills of the central and northern part of the State. Their fall is rapid, with frequent vertical drops over granite ledges. Building stone is abundant in nearly all the drainage basins. The rocky beds furnish excellent foundations for dams and mills, and the excellent harbors along the coast, together with the railroad lines following the lower courses of the streams, give for a large part of the State excellent transportation facilities. The extensive lake areas, aggregating 2,300 square miles, furnish natural reservoirs for the storage of storm

waters that could not be equaled throughout the United States. In addition to the lakes, the extensive forests covering the greater part of the State and the gravelly and porous soil tend to make the flow of the Maine rivers remarkably uniform.

During the summer of 1901 the United States Geological Survey commenced the hydrographic study of the State of Maine. Prior to that time records of flow from a few of the main rivers had been furnished by engineers and manufacturing companies and published in the reports of the Survey. It is hoped that these records may be continued and that the investigations may be extended, so that definite information may be obtained of the flow, fall, and the possibilities of increased storage on all of the larger streams of the State.

In the following pages the records of flow for the year 1902 are published for all stations for which such figures are available. In addition to these, gage heights are given at a number of the new stations established by the Survey, with the results of current-meter measurements made from time to time. As soon as these stations have been continued for a sufficient period to permit of the construction of rating curves for the stations, the records of flow for each day of the year will be published.

Twelve gaging stations are now being maintained by the Geological Survey in the State of Maine. These stations are under the charge of N. C. Grover, professor of civil engineering, University of Maine, assisted by F. E. Pressey. The stations are located as follows: On the Androscoggin River at Dixfield; on the Kennebec River at The Forks and North Anson; on the Carrabassett River near North Anson; on the Dead River near The Forks; on the Moose River near Rockwood; on the Roach River at Roach River; on the East Branch of the Penobscot at Grindstone; on the Penobscot at Montague; on the Mattawamkeag at Mattawamkeag; on the Piscataquis at Low's bridge between Foxcroft and Guilford; and on the St. Croix at Sprague's Falls.

Aside from the records at these stations, records are also received from various engineers, as noted in the following pages.

A full description of the drainage areas of the Maine rivers will be found in Water-Supply and Irrigation Paper No. 69, and records of flow for past years will be found in the same paper.

ST. CROIX RIVER DRAINAGE BASIN.

St. Croix River is formed by two branches, known as the Upper St. Croix or Chiputneticook River, the outlet of the Schoodic Lakes, and Kennebasis River, the outlet of the western lakes of the area, known as the Kennebasis Lakes. The Upper St. Croix, with its tributary lakes, forms nearly half of the eastern boundary of Maine, separating that State from New Brunswick. The total drainage area of the main stream is about 1,630 square miles, of which 960 square miles are tributary to the great reservoir systems controlled by dams.

anceboro and Princeton. The length of the stream from the headaters to the mouth is 100 miles. The basin is, in general, lower an that of any of the larger streams of the State flowing into the tlantic, its headwaters having an elevation of about 540 feet. The ll from Chiputneticook Lake (the lower of the Schoodic Lakes) to le water, a distance of 54 miles, is, however, 382 feet, or 7 feet to the ile, and there are a number of places where falls and rapids occur which water power has been or can easily be developed.

The lake system of the St. Croix is the largest in the State in proortion to the drainage basin, except that of the Presumpscot, and the lakes act as a regulator of flow and can easily be improved for reater duty, St. Croix River may be considered one of the best waterower streams on the Atlantic coast. The lake system of the Upper t. Croix comprises approximately 50 square miles of lake surface, nd that of the West Branch 70 square miles, considering only the rincipal lakes and ponds. Indeed, above Vanceboro and Princeton ach branch of the river is simply a succession of lakes to almost the xtreme headwaters. Wells estimated the total lake surface of the t. Croix as not less than 150 square miles, or nearly one-tenth of ne total drainage area. The drainage area at various points on the ver is given in the following table:

Drainage area of St. Croix River.

ain river:	Sq. miles.
Vanceboro dam, foot of the Schoodic Lakes	420
Little Falls	500
Immediately above mouth of West Branch	690
Immediately below mouth of West Branch	1,360
Sprague Falls	1,390
Calais, lower dam	1,530
Mouth of river, eastern border of town of Calais	1,630
Vest Branch:	
Princeton dam	500
Confluence with main river	670

A large proportion of the drainage basin is still covered with timer, and above Vanceboro and Princeton the region is for the most art wild and inaccessible, being visited only by lumbermen and portsmen. The greater part of the timber in this region is controlled y sawmill owners at Calais and St. Stephen. In 1898 the amount f lumber sawed annually had fallen from about 100,000,000 feet to 5,000,000 feet, and since then the number of sawmills has been reatly reduced. In 1901 the lumber sawed amounted to 28,000,000 eet, showing that the rate of cutting has remained nearly constant uring the last few years. There are on this stream favorable locaions for paper and pulp mills, but arrangements would have to be nade with the sawmill owners in order to obtain a supply of timber.

The river is navigable as far as Calais, except during two months f the year, when it is frozen. Calais has railroad connection with

Bangor directly over the Washington County Railroad, and, by way of Vanceboro, over the Canadian Pacific and the Maine Central railroads. There is also a short road connecting Princeton with Calais. Above Princeton the transportation facilities are poor. Calais, Princeton, and Vanceboro, in Maine, and St. Stephen, in New Brunswick, are towns with populations of from 1,000 to 10,000, largely engaged in the manufacture of lumber.

ST. CROIX RIVER AT SPRAGUES FALLS, NEAR BARING, ME.

This station was established December 4, 1902, by F. E. Presey. The drainage area at this point is 1,390 square miles. The usual form of wire gage is attached to the lower guard timber of the Washington County Railroad Bridge. It is referenced by a bench mark on the down-stream corner of bridge seat on right abutment; elevation 17.0 feet above zero of gage. The gage is read daily by Simeon Phinney, section foreman on the Washington County Railroad, who resides at Baring, Me. The measurements of flow are made from a car suspended on a steel cable, which is stretched over the river about one-half mile above the bridge. The channel is straight 100 feet above and 1,000 feet below the cable. The banks are high and rocky, and the bed is rocky. The station is best reached by carriage from Calais, Me., because trains run so infrequently on this branch of the Washington County Railroad.

Daily gage height, in feet, of St. Croix River, at Sprague Falls, near Baring, Me., for December, 1902.

Day.	Dec.	Day.	Dec.	Day.	Dec.	Day.	Dec.
4	6.9	11	8.4	18	9.0	25	
5	7.1	12	8.6	19	9.1	26	
6	7.2	13	8.7	20	8.8	27	
7	7.4	14	9.0	21	8.8	28	
8	7.8	15	9.7	22	8.7	29	
9	8.0	16	9.7	23	8.9	30	
10	8.3	17	8.5	24	9.1	31	

PENOBSCOT RIVER DRAINAGE BASIN.

The Penobscot has the largest drainage basin of all the rivers in Maine, comprising about 8,500 square miles, or more than one-quarter of the entire State. Its greatest length from north to south is 150 miles, its greatest width 115 miles, all within the State. Eight hundred square miles of the basin discharge their waters into the main river below its lowest water power at Bangor.

The basin is at a lower elevation above the sea than the basins of the Kennebec and the Androscoggin, as would be expected from the general southeasterly slope of the country toward the Atlantic Ocean. The northern portion, however, is rather elevated, having a mean

ight of about 1,000 feet. The highest portion of the basin is at the adwaters of the main river, where the elevation is from 1,600 to 00 feet.

Taken as a whole, the basin is rather uniform in its topographic atures. Hills and low mountains stretch from near the sea to above ngor; farther north is an undulating plain, while to the west e surface becomes more broken and greatly diversified by hills, tached peaks, lakes, ponds, and swamps. At the south the basin erges into that of the Kennebec, and at the north into that of the lleguash, terminating on the northwest, at the boundaries of the ate, in a highland region intermingled with swamps and lagoons, e latter furnishing water to the Penobscot and the St. John. A rge part of the basin is what is known as "wild land," being heav- timbered and known only to the lumberman and the sportsman. ew regions in the country are more delightful to the lover of nature an the forests, the lakes, and the mountains on the headwaters of e Penobscot. From Mount Katahdin, the highest mountain of the ate, a view can be obtained in all directions, overlooking the exten- ve plain and showing vast stretches of forests dotted here and there ith lakes.

Over the upper portion of the basin slate is the principal surface ck, being succeeded to the east and south by schists, gneiss, and anite; the soil is mainly gravel, clay, and loam.

The drainage areas of the river and its chief tributaries are given the following table:

Drainage areas of Penobscot River and principal tributaries.[a]

River.	Locality.	Drainage area.
		Square miles.
nobscot	Opposite northwest extremity of Moosehead Lake, township of Seboomook, immediately below mouth of Nulhedus Creek.	510
Do	Entrance into Chesuncook Lake	850
Do	Outlet of Chesuncook Lake	1,450
Do	Millinocket, outlet of Twin Lakes	1,880
Do	Immediately below mouth of east branch of Penobscot.[a]	3,260
Do	Immediately below mouth of Mattawamkeag.[a]	4,940
Do	Montague, immediately below mouth of Piscataquis.[a]	6,630
Do	Sunk Haze Rips[a]	7,260
Do	Old Town, above mouth of Pushaw River[a]	7,340
Do	Bangor, above mouth of Kenduskeag River[a]	7,720

[a] Includes Chamberlain Lake Basin (270 square miles).

Drainage areas of Penobscot River and principal tributaries—Continued.

River.	Locality.	Drainage area.
		Square miles.
Penobscot	Mouth [a]	8,570
Cauquomogomoc	Entrance into Chesuncook Lake	300
East branch of Penobscot.	Grindstone [a]	1,400
Do	Mouth [a]	1,630
Mattawamkeag	Immediately below outlet of Baskahegan Lake.	700
Do	Mouth	1,100
Piscataquis	Low's bridge	500
Do	Dover	800
Do	Mouth	1,700
Passadumkeag	....do	400

[a] Includes Chamberlain Lake basin (270 square miles).

The river naturally has a comparatively uniform flow throughout the year, which is due to the extent of the tributary area, its extensive system of lakes, the vast breadth of forests upon its drainage surfaces, and the more uniform surface of the basin, in which particular it has decided advantage over the Saco, the Androscoggin, and the Kennebec.

PENOBSCOT RIVER AT MONTAGUE, ME.

A gaging station was established by N. C. Grover at Montague November 5, 1901. The station is located at the highway bridge across the Penobscot, about 1,000 feet below the mouth of the Piscataquis River. The drainage area at this point is 6,630 square miles, of which 270 square miles is the area of Chamberlain Lake, which flows into the Penobscot only part of the year. The measurements are made from the bridge. A wire gage of the usual type is fastened to the guard timber on the upper side of the bridge. It is graduated to feet and tenths and is referred to a bench mark, the top of the northwest corner of second course below bridge seat, easterly abutment, the elevation being 25.78 feet above zero of the gage. The initial point of soundings is at the extreme end of the inclined end post on upstream side of bridge. The channel is straight for 1,000 feet above and 3,000 feet below the station, and the current is swift. The banks are high and rocky, and the bed rocky, with some gravel. The gage is read twice daily—7 a. m. and 5 p. m.—by A. H. Hanson, merchant in Montague.

Discharge measurements of Penobscot River at Montague, Me.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Second-feet.*
vember 5	F. E. Pressey	2.00	3,034
1902.			
rch 28	do	12.90	57,427
ril 8	do	11.00	43,937
y 15	N. C. Grover	5.30	11,271
gust 28	F. E. Pressey	4.00	7,575
tember 15	do	4.10	7,778
tober 11	R. M. Connor	3.95	7,446

Daily gage height, in feet, of Penobscot River at Montague, Me.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	5.30	5.15	(a)	14.60	9.30	6.35	7.60	5.45	2.35	3.10	7.00	4.30
	4.05	5.15		14.05	10.75	6.20	7.50	5.35	2.95	3.20	6.10	4.25
	4.45	5.35		13.45	10.30	6.25	7.55	5.15	3.10	3.05	5.40	3.90
	4.60	5.20		12.90	10.05	7.55	7.60	5.00	3.45	3.05	5.15	3.55
	4.40	5.05		12.35	9.80	9.30	7.50	5.25	3.30	2.95	5.25	3.90
	4.20	5.00		11.50	9.60	10.15	7.15	5.20	3.20	2.75	5.00	3.80
	4.15	4.90		11.15	9.50	10.25	6.75	5.10	3.15	3.30	4.55	3.70
	3.70	4.80		10.95	9.40	10.10	6.30	5.20	2.90	3.90	4.35	5.00
	3.75	(a)		10.75	9.30	12.00	6.25	5.30	2.45	4.15	4.15	(a)
	3.60			10.90	9.10	12.30	6.05	5.15	3.10	4.05	3.90	
	3.10			11.15	8.75	11.55	5.80	5.00	3.65	3.85	4.05	
	3.00			11.25	8.40	11.00	5.25	5.40	3.85	3.30	4.10	
	2.90			11.15	8.10	10.50	5.40	6.25	3.65	3.25	4.15	
	2.95			10.80	7.70	10.10	6.15	6.45	3.75	3.05	4.20	
	2.80			10.45	7.35	9.70	5.30	6.60	4.00	3.30	4.30	
	2.70			10.40	7.00	9.15	4.80	5.00	3.85	3.15	4.40	
	2.55			10.25	6.70	8.50	4.90	5.15	3.70	3.20	4.25	
	2.30			10.05	6.70	8.15	4.95	5.00	3.60	3.15	4.30	
	2.55			9.55	6.60	7.75	5.10	5.40	3.50	3.00	4.45	
	2.30			8.75	6.35	7.15	5.25	6.25	3.35	2.95	4.40	
	2.65			8.85	6.05	6.50	5.90	5.95	3.35	3.50	4.30	
	2.70			9.10	6.25	6.45	6.10	6.60	3.40	4.10	4.30	
	3.90			9.00	6.45	7.70	5.85	5.00	3.35	3.90	4.30	
	6.30			8.90	6.80	7.60	4.95	4.35	3.30	3.50	4.05	
	6.65			9.00	6.80	7.25	4.70	3.60	3.25	3.25	4.05	
	5.65			9.10	6.95	7.20	4.80	3.70	3.20	3.05	4.25	
	5.85			9.15	6.85	9.55	4.55	3.95	3.10	3.05	4.00	
	6.20		12.80	9.35	6.80	9.85	5.05	4.00	2.95	3.90	4.05	
	6.35		12.80	9.35	7.10	8.65	5.85	3.70	2.80	7.90	4.05	
	5.65		14.55	9.30	7.05	8.05	5.90	3.45	2.95	8.20	4.40	
	5.75		15.10		6.70		5.80	2.95		7.60		

a Frozen February 5 to March 27 and December 9 to 31.

Rating table for Penobscot River at Montague, Me., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.0	3,034	5.4	11,715	8.8	28,206	12.2	52,325
2.2	3,502	5.6	12,299	9.0	29,605	12.4	53,747
2.4	3,970	5.8	13,015	9.2	31,025	12.6	55,195
2.6	4,438	6.0	13,763	9.4	32,445	12.8	56,585
2.8	4,906	6.2	14,543	9.6	33,865	13.0	58,010
3.0	5,374	6.4	15,355	9.8	35,285	13.2	59,435
3.2	5,842	6.6	16,199	10.0	36,705	13.4	60,845
3.4	6,310	6.8	17,075	10.2	38,125	13.6	62,265
3.6	6,778	7.0	17,985	10.4	39,545	13.8	63,685
3.8	7,246	7.2	18,925	10.6	40,965	14.0	65,105
4.0	7,714	7.4	19,897	10.8	42,385	14.2	66,525
4.2	8,193	7.6	20,901	11.0	43,805	14.4	67,945
4.4	8,701	7.8	21,940	11.2	45,225	14.6	69,365
4.6	9,241	8.0	23,050	11.4	46,645	14.8	70,785
4.8	9,813	8.2	24,240	11.6	48,065	15.0	72,205
5.0	10,417	8.4	25,510	11.8	49,485		
5.2	11,053	8.6	26,842	12.0	50,905		

Estimated monthly discharge of Penobscot River at Montague, Me.

[Drainage area, 6,630 square miles.]

Month.	Discharge in second-feet.			Run-off	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1901.					
November 5 to 30			[a] 3,466	[a] 0.52	
December	68,655	3,034	14,583	2.20	
1902.					
January	16,415	3,736	8,354	1.26	
February 1 to 8 [b]			[a] 10,662	[a] 1.61	
March 28 to 31 [b]			[a] 63,774	[a] 9.62	
April	69,365	27,862	40,862	6.16	
May	42,030	13,955	23,694	3.57	
June	53,035	14,543	29,024	4.38	
July	20,901	9,103	13,737	2.07	
August	16,199	5,257	10,788	1.63	
September	7,714	3,853	6,037	0.91	
October	24,240	4,789	7,787	1.17	
November	17,985	7,480	9,149	1.38	
December 1 to 8 [b]			[a] 7,882	[a] 1.19	

[a] Partial month.

[b] River frozen for remainder of the month.

PENOBSCOT RIVER AT MILLINOCKET, ME.

The discharge of the Penobscot at Millinocket since January 11, 901, has been computed from data furnished by H. S. Ferguson, ngineer for the Great Northern Paper Company. These results were btained by adding to the flow through the wheels the flow over the m. The wheels were rated at Holyoke, Mass., before being placed position. As the head under which they work, averaging about 0 feet, is much greater than the head under which they were tested, veral tube float measurements of the flow in the canal leading to e mill have been made by Mr. Ferguson in order to determine just w much water the mill uses under different conditions of gate open-gs. By means of these measurements it is believed that a very good timate has been made of the flow through the wheels. The dam is concrete, resting on ledge, and does not leak. The flow over it was mputed by use of the formula $Q=c\ b\ H^{\frac{3}{2}}$, in which c is a variable efficient obtained from a study of the results of experiments made y George W. Rafter at the Cornell testing flume.

The area of the drainage basin at Millinocket is 1,880 square miles. he following tables give the record of flow for the years 1901 and 1902:

Mean daily flow, in second-feet, of Penobscot River at Millinocket, Me.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
		1,580	1,740	1,710	20,220	2,580	2,580	1,800	2,310	2,000	760	410
		1,670	1,510	1,370	19,360	2,680	2,490	1,980	3,600	1,960	690	470
		2,250	1,450	1,680	18,030	2,760	2,680	1,690	3,280	1,960	570	470
		1,410	1,680	2,000	17,240	2,440	3,310	2,830	2,130	1,950	710	460
		1,840	1,930	1,920	16,280	2,550	1,540	1,760	1,940	1,540	760	450
		1,630	1,510	2,180	15,030	2,490	1,930	2,000	1,930	1,740	700	440
		1,210	1,410	2,800	14,000	2,550	2,420	1,910	1,810	1,990	510	430
		1,660	1,300	3,210	9,240	2,680	2,710	2,850	3,750	1,940	490	420
		1,910	1,160	4,890	6,130	2,540	2,890	3,960	3,110	1,960	330	860
		1,480	1,470	4,420	5,280	2,770	2,600	3,930	1,940	1,950	1,090	840
	1,310	1,050	1,930	5,430	3,410	2,770	2,450	6,500	1,880	1,600	1,020	850
	960	1,740	1,510	6,030	2,740	2,480	2,630	6,440	1,970	1,240	760	450
	1,200	2,360	1,510	5,920	2,790	2,780	3,450	2,030	1,940	980	630	450
	1,500	1,890	1,720	6,400	2,980	2,960	2,830	1,940	1,820	1,530	1,230	470
	1,460	1,860	1,510	8,610	3,130	3,200	6,790	2,060	3,860	1,320	760	780
	1,310	2,000	2,080	8,880	3,320	3,370	3,820	2,200	3,880	1,250	750	1,760
	1,260	1,230	1,450	9,800	4,130	3,370	4,010	1,980	1,950	1,130	380	1,520
	1,430	1,650	1,610	12,390	3,830	2,350	3,520	2,910	3,010	1,470	790	1,530
	1,450	1,440	1,770	12,820	4,650	2,240	7,600	2,160	3,980	1,650	720	1,890
	1,390	1,550	1,830	14,020	4,750	2,450	8,140	2,040	3,360	1,420	440	1,720
	1,500	1,390	1,410	15,770	3,250	2,300	3,850	2,040	3,150	1,020	450	1,800
	1,780	1,760	1,370	17,230	2,260	2,360	6,880	1,990	4,470	990	450	1,880
	1,000	1,450	1,420	19,210	2,010	2,570	3,310	1,970	4,050	1,120	360	1,710
	1,700	1,600	1,480	11,360	1,520	2,400	2,270	1,980	1,930	790	390	1,710
	1,410	1,640	1,780	10,410	1,780	2,800	2,380	2,020	1,910	1,060	400	990
	2,060	1,380	1,910	10,650	1,890	2,710	2,120	4,880	1,920	1,010	450	1,900
	1,560	1,420	1,510	20,040	3,440	2,560	2,860	2,700	1,960	610	860	1,810
	1,590	1,600	1,940	22,110	2,690	2,280	2,260	1,910	1,830	840	960	1,700
	1,390		1,940	20,360	2,980	2,760	6,250	1,950	1,360	730	450	1,760
	1,170		1,990	20,240	2,570	2,860	6,250	1,790	1,960	750	810	2,000
	1,600		1,350		3,050		3,240	1,910		780		1,960

Mean daily flow, in second-feet, of Penobscot River at Millinocket, Me.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2,230	1,930	2,140	13,150	11,180	4,130	3,040	2,520	2,300	2,140	2,5[illegible]	[illegible]
2	2,860	2,630	2,110	14,110	11,180	2,890	2,820	2,520	2,640	2,030	2,[illegible]	[illegible]
3	2,160	2,180	2,110	13,820	11,190	5,430	2,580	1,570	2,160	2,050	4,[illegible]	[illegible]
4	2,160	2,090	2,110	13,380	11,070	6,300	460	2,540	2,540	2,080	2,[illegible]	[illegible]
5	2,130	2,110	2,110	14,050	11,420	11,600	330	2,440	2,190	2,330	2,[illegible]	[illegible]
6	2,010	2,040	2,100	14,050	12,600	11,600	1,420	2,540	2,150	2,540	2,5[illegible]	[illegible]
7	2,040	2,100	2,180	15,030	12,580	12,440	2,560	2,560	1,790	2,430	2,[illegible]	[illegible]
8	2,010	1,940	2,340	14,120	15,030	17,240	2,570	2,510	2,420	2,300	2,[illegible]	[illegible]
9	2,020	3,440	2,350	13,240	13,380	20,040	2,570	2,980	2,180	2,250	2,[illegible]	[illegible]
10	1,950	2,120	2,530	13,180	12,960	19,370	2,560	2,820	2,420	2,200	2,[illegible]	[illegible]
11	1,740	2,020	2,320	13,170	14,840	20,590	2,560	2,250	2,380	2,100	2,[illegible]	[illegible]
12	2,030	2,000	2,820	13,070	12,140	20,230	2,560	2,450	2,170	1,940	2,[illegible]	[illegible]
13	2,030	2,060	2,820	13,340	12,150	17,510	2,380	2,430	2,070	2,110	2,[illegible]	[illegible]
14	2,030	1,970	2,700	13,210	10,470	15,590	2,550	2,410	1,780	2,450	2,[illegible]	[illegible]
15	2,020	1,870	2,690	12,310	16,920	11,860	2,570	2,500	2,100	2,150	2,[illegible]	[illegible]
16	2,190	3,090	2,500	12,400	6,350	11,600	2,550	2,430	2,110	2,770	2,[illegible]	[illegible]
17	2,030	3,370	5,500	12,390	6,220	10,870	2,560	2,010	2,560	2,430	2,[illegible]	[illegible]
18	1,910	2,080	5,360	12,010	9,590	10,980	2,560	2,220	2,110	2,640	2,[illegible]	[illegible]
19	2,560	2,110	6,430	6,770	9,050	7,710	2,540	2,280	2,070	2,330	2,[illegible]	[illegible]
20	1,980	2,120	6,980	8,380	7,680	9,560	2,290	4,380	2,080	2,460	2,[illegible]	[illegible]
21	1,950	2,130	8,760	9,030	5,880	3,210	2,550	4,330	1,910	2,180	2,[illegible]	[illegible]
22	1,970	2,020	8,580	7,840	8,820	3,930	2,550	4,310	2,120	2,490	2,[illegible]	
23	2,070	3,440	8,190	7,940	8,920	3,930	2,550	3,870	2,080	2,170	1,[illegible]	[illegible]
24	1,960	2,110	9,950	7,950	8,800	3,570	2,560	1,890	2,120	2,160	2,[illegible]	[illegible]
25	2,080	2,120	9,910	9,740	6,220	3,290	2,550	2,480	2,130	2,170	2,[illegible]	
26	2,660	2,130	9,790	10,180	5,940	3,290	2,530	2,280	2,140	1,960	2,[illegible]	[illegible]
27	1,950	2,140	9,820	11,390	8,260	3,270	2,370	2,460	2,110	2,150	2,[illegible]	[illegible]
28	1,800	2,120	9,790	11,740	3,090	3,900	2,560	2,410	1,870	2,570	2,[illegible]	[illegible]
29	3,270	.....	9,840	11,190	3,120	2,970	2,800	2,330	2,080	2,580	2,[illegible]	[illegible]
30	2,170	.....	9,970	11,200	3,110	2,870	2,590	2,450	2,480	2,160	1,[illegible]	[illegible]
31	2,160	.....	9,970	.....	3,110	.....	2,700	1,930	.....	2,330	.....	[illegible]

Estimated monthly discharge of Penobscot River at Millinocket, Me.

[Drainage area, 1,880 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1901.					
uary 11 to 31	2,060	960	1,430	0.76	0.88
ruary	2,360	1,050	1,629	.87	.91
rch	2,030	1,160	1,617	.86	.99
ril	22,110	1,370	9,447	5.02	5.60
y	20,220	1,520	6,578	3.50	4.04
ie	3,370	2,240	2,654	1.41	1.57
y	8,140	1,540	3,599	1.91	2.20
gust	6,500	1,690	2,584	1.37	1.58
tember	4,470	1,360	2,600	1.38	1.54
tober	2,000	610	1,364	.73	.84
vember	1,230	330	656	.35	.39
cember	2,000	410	1,158	.62	.71
The year	22,110	330	2,943	1.56	21.25
1902.					
nuary	3,270	1,740	2,133	1.13	1.30
bruary	3,440	1,870	2,266	1.21	1.26
arch	9,970	2,100	5,380	2.86	3.30
ril	15,030	6,770	11,777	6.26	6.98
ay	16,920	3,090	9,460	5.03	5.80
ne	20,590	2,870	9,392	5.00	5.58
ly	3,040	330	2,398	1.28	1.48
gust	4,380	1,570	2,615	1.39	1.60
ptember	2,640	1,780	2,174	1.16	1.29
tober	2,770	1,940	2,287	1.22	1.41
ovember	4,860	1,350	2,447	1.30	1.45
ecember	5,390	570	2,658	1.41	1.63
The year	20,590	330	4,582	2.44	33.08

EAST BRANCH OF PENOBSCOT RIVER AT GRINDSTONE, ME.

This station was established October 23, 1902, by F. E. Pressey. It is located at the Bangor and Aroostook Railroad bridge, one-half mile south of the hotel. The measurements are made from the railroad bridge. The drainage area at this point is 1,130 square miles, including the Chamberlain Lake basin (270 square miles). The initial point for soundings is on the left bank, at the lower end of the inclined end post. The gage is of the usual wire type, and the scale board, graduated to feet and tenths, is nailed to the guard timber on the upper side of the bridge. The gage is read daily, at 7 a. m. and 5. p. m., by L. B. Trask. The channel both above and below this station is straight. The bed of the stream is rocky, and the stream is confined in the channel by the abutments of the bridge. The bench mark is located on the east abutment, at the southwest corner of the bridge seat. Elevation, 26.32 feet above the zero of the gage. During 1902 the following measurements were made by F. E. Pressey:

October 23: Gage height, 5.15 feet; discharge, 706 second-feet.
November 26: Gage height, 5.41 feet; discharge, 921 second-feet.

Daily gage height, in feet, of East Branch of Penobscot River at Grindstone, Me., for 1902.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	.....	6.15	5.50	12	.....	5.65	5.30	23	5.15	5.0	...
2	.....	6.05	5.50	13	.....	5.80	5.30	24	5.10	5.6	...
3	.....	5.90	5.40	14	.....	5.55	(a)	25	5.10	5.5	...
4	.....	5.90	5.20	15	.....	5.50	.....	26	5.10	5.5	...
5	.....	5.90	5.20	16	.....	5.50	.....	27	5.10	5.6	...
6	.....	5.80	5.30	17	.....	5.70	.....	28	5.50	5.5	...
7	.....	5.80	5.30	18	.....	5.60	.....	29	7.65	5.5	...
8	.....	5.70	5.30	19	.....	5.55	.....	30	7.05	5.5	...
9	.....	5.65	5.30	20	.....	5.50	.....	31	6.45	...	...
10	.....	5.70	5.30	21	.....	5.55	.....				
11	.....	5.60	5.30	22	.....	5.60	.....				

a Frozen from December 14 to 31.

MATTAWAMKEAG RIVER AT MATTAWAMKEAG, ME.

This station was established August 26, 1902, by F. E. Pressey. It is located at the Maine Central Railroad bridge over the Mattawamkeag River in the town of Mattawamkeag. The area of the drainage basin at this point is 1,510 square miles. The initial point for soundings is on the left bank, at the south end of the bridge, at the lower end of the inclined end post. The gage is of the usual wire type, and the scale board, which is graduated to feet and tenths, is nailed to the guard timber of the lower side of the bridge. The gage is read at 7 a. m. and 4 p. m. by Leon D. Mincher. The channel both above and below this station is straight, and the bed of the stream is rocky at

water is confined to the channel by the abutments of the bridge. e bench mark is on the north abutment at the southwest corner of bridge seat. Its elevation is 26.78 feet above the zero of the gage. The following discharge measurements were made during 1902 by E. Pressey:

July 31: Gage height, 4.4 feet; discharge, 1,318 second-feet.
August 27: Gage height, 4.7 feet; discharge, 1,847 second-feet.
September 16: Gage height, 5.0 feet; discharge, 1,970 second-feet.
November 8: Gage height, 5.89 feet; discharge, 3,556 second-feet.

ily gage height, in feet, of Mattawamkeag River at Mattawamkeag, Me., for 1902.

ay.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
.....	.....	4.10	4.60	7.85	5.65	17.....	.....	5.00	4.80	5.50	7.00
.....	.....	4.05	4.60	7.40	5.45	18.....	.....	4.90	4.80	5.50	7.45
.....	.....	4.40	4.60	7.00	5.45	19.....	.....	4.85	4.80	5.50	7.80
.....	.....	4.70	4.55	6.65	5.25	20.....	.....	4.70	4.85	5.50	(a)
.....	.....	4.60	4.40	6.35	5.35	21.....	.....	4.50	5.05	5.40	.....
.....	.....	4.60	4.45	6.10	5.30	22.....	.....	4.40	5.20	5.50	.....
.....	.....	4.50	4.75	6.00	5.35	23.....	.....	4.40	5.15	5.50	.....
.....	.....	4.40	5.25	5.90	7.25	24.....	.....	4.40	5.00	5.50	.....
.....	.....	4.30	5.45	5.75	7.05	25.....	.....	4.35	4.85	5.50	.....
.....	.....	4.45	5.40	5.65	6.70	26.....	4.60	4.40	4.70	5.45	.....
.....	.....	4.50	5.20	5.45	6.45	27.....	4.70	4.40	4.65	5.35	.....
.....	.....	4.60	5.10	5.30	6.40	28.....	4.60	4.25	5.05	5.40	.....
.....	.....	4.70	4.95	5.25	(a)	29.....	4.50	4.30	6.80	5.55	.....
.....	.....	4.80	4.90	5.20	.....	30.....	4.40	4.35	7.80	5.70	.....
.....	.....	4.80	4.80	5.30	.....	31.....	4.25	.....	8.00	.....	.....
.....	.....	5.00	4.80	5.40	.....						

a Frozen December 13 to 16 and 20 to 31.

PISCATAQUIS RIVER AT LOW'S BRIDGE, NEAR FOXCROFT, ME.

This station was established August 17, 1902, by F. E. Pressey. It located at Low's bridge, about half way between Guilford and Foxcroft, Me. The area of the drainage basin at this point is 280 square miles. The initial point for soundings is on the left bank, at the ream side edge of the top stone of the left abutment. The gage is painted staff, graduated to feet and tenths, spiked to the left abutment. It is read at 7 a. m. and 5 p. m. by A. F. D. Harlow. The hannel both above and below the station is straight, the banks are igh and gravelly, and the bed is rocky. The bench mark is on the ft abutment, at the top of the second course from the top. Elevation, 17.8 feet above the zero of the gage.

The following discharge measurements were made during 1902 by . E. Pressey:

August 13: Gage height, 3.7 feet; discharge, 998 second-feet.
August 16: Gage height, 2.8 feet; discharge, 332 second-feet.
September 10: Gage height, 2.75 feet; discharge, 288 second-feet.
October 18: Gage height, 2.0 feet; discharge, 61 second-feet.

Daily gage height, in feet, of Piscataquis River at Low's bridge, near Foxcroft, Me., for 1902.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	2.45	2.65	3.90	3.05	17	2.45	3.15	2.80	3.50	.....
2	.....	2.35	2.65	3.55	3.00	18	2.75	2.85	2.35	3.35	.....
3	.....	2.40	2.55	3.50	2.90	19	2.55	2.75	2.00	3.05	.....
4	.....	2.40	2.45	3.50	2.80	20	2.50	2.75	2.90	3.25	.....
5	.....	2.50	2.40	3.30	2.70	21	2.85	2.70	3.35	3.25	.....
6	.....	2.40	2.30	3.35	(a)	22	2.65	2.65	3.10	3.15	.....
7	.....	2.35	2.90	3.10	.....	23	2.40	2.55	2.95	3.05	.....
8	.....	2.55	3.15	3.15	.....	24	2.35	2.70	2.95	3.05	.....
9	.....	2.55	3.10	3.00	.....	25	2.65	2.60	2.90	3.00	.....
10	.....	3.30	2.95	3.10	.....	26	2.70	2.60	2.70	3.00	.....
11	.....	3.60	2.75	2.90	.....	27	2.75	2.55	2.75	2.90	.....
12	.....	3.25	2.50	3.25	.....	28	2.70	2.20	4.00	3.05	.....
13	.....	2.45	2.70	3.85	.....	29	2.50	2.35	6.25	3.00	.....
14	.....	2.70	2.35	3.50	.....	30	2.45	2.65	5.10	2.85	.....
15	.....	2.95	2.10	3.40	.....	31	1.75	.....	4.25	.....	.....
16	.....	3.15	2.15	3.30	.....						

a Frozen December 6 to 31.

Rating table for Piscataquis River at Low's bridge, near Foxcroft, Me., for

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.0	60	2.6	230	3.2	595	3.8	1,075
2.1	75	2.7	270	3.3	675	3.9	1,155
2.2	100	2.8	320	3.4	755	4.0	1,235
2.3	125	2.9	380	3.5	835	.....	.....
2.4	160	3.0	445	3.6	915	.....	.....
2.5	195	3.1	515	3.7	995	.....	.....

Estimated monthly discharge of Piscataquis River at Low's bridge, near Foxcroft, Me.

[Drainage area, 280 square miles.]

Month.	Discharge in second-feet.			Run-off
	Maximum.	Minimum.	Mean.	Second-feet per square mile.
1902.				
August 17 to 31	.....	.....	218	0.78
September	1,155	100	299	1.07
October	3,035	60	506	1.81
November	1,155	320	638	2.28
December 1 to 5	480	270	379	1.35

KENNEBEC RIVER DRAINAGE BASIN.

Kennebec River is one of the best streams in the United States for development of water power. Its basin lies between those of the droscoggin and the Penobscot and extends from the Canada line to ocean. The basin measures 150 miles in length and varies in dth from 50 to 80 miles in the main portion, embracing a total area 6,110 square miles. Of this area, 1,330 square miles are tributary Moosehead Lake.

The river rises in Moosehead Lake, though its headwaters are col-ted by Moose River, Roach River, and a number of smaller streams ing in the hilly, forested areas lying to the east and west of that ke. The northern part of the drainage basin is broken by offsets m the White Mountains. Nearly the whole of the upper portion the drainage area is forest covered and in its original wild state. low the outlet of Moosehead Lake the hills close in upon the river, rming a narrow, rocky chasm, with steep and precipitous sides. om Moosehead Lake to The Forks the river is a torrent, falling er a rocky bed 500 feet in a distance of 23 miles. At The Forks e waters of Dead River, which rises near the western boundary of e State at an elevation of about 2,000 feet, are joined to the main ream. Below this junction the river flows through a broad vaylle, ith gentle slopes upon either side, still covered to some extent with rest growth, but largely cleared and with occasional cultivated rms. About 60 miles from the coast the hills again rise, though not a considerable height. There are on the river a number of large lls, which have been developed by the construction of dams and are ow used for sawmills, pulp mills, and cotton mills.

The prevailing rock in the northern part of the basin is slate, with belt of sandstone to the west and a district of granite to the east of Moosehead. South of Bingham mica-schists run into the clay slate n spots and elsewhere into gneiss, but (except where broken by ntrusions of granite, as at Hallowell and Augusta) the slate prevails s far as Gardiner. Below the latter city gneiss predominates, with tretches of mica-schists on the east bank. The surface materials re finely pulverized, and water-retaining sands and gravels are more bundant in the northern part, succeeded by a greater proportion of oam and clay to the south.

The areas of the drainage basins of the river and its principal tributaries are given in the following table:

Drainage areas of Kennebec River and principal tributaries.

River.	Locality.	Drainage area
		Square miles
Kennebec	Outlet of Moosehead Lake	[illegible]
Do	The Forks	[illegible]
Do	Immediately below mouth of Dead River	[illegible]
Do	Carritunk Falls, Solon	[illegible]
Do	North Anson, above mouth of Carrabassett River.	[illegible]
Do	Madison	[illegible]
Do	Norridgewock	[illegible]
Do	Fairfield	[illegible]
Do	Waterville, above mouth of Sebasticook River.	[illegible]
Do	Waterville, below mouth of Sebasticook River.	[illegible]
Do	Augusta	[illegible]
Do	Head of Merrymeeting Bay	[illegible]
Moose	Mouth	[illegible]
Roach	Roach River	[illegible]
Dead	Mouth, The Forks	[illegible]
Carrabassett	North Anson, above Embden Brook	[illegible]
Sandy	Farmington	[illegible]
Do	Mouth	[illegible]
Sebasticook	----do	[illegible]
Messalonskee	----do	[illegible]
Cobbosseecontee	----do	[illegible]

The United States Geological Survey now maintains gaging stations at the following places on the Kennebec drainage: On the Kennebec at The Forks and at North Anson, on the Carrabassett River at North Anson, on Dead River at The Forks, on Moose River at Rockwood, and on Roach River at Roach River.

Since 1892 records have been kept at Waterville by the Hollingsworth & Whitney Pulp and Paper Company. Records for the years 1901 and 1902 are published in this report.

KENNEBEC RIVER AT THE FORKS, ME.

This station was established by N. C. Grover, September 28, [illegible] at the bridge across the Kennebec River at The Forks. The gage is a vertical rod, graduated to feet and tenths, and referred to bench mark which is the top of a bolt on east abutment, north side of bridge; the elevation of the bench mark is 12.85 feet above zero of the gage. The initial point of soundings is on the left bank marked by a rod across the bridge, just above the abutment and below

e bridge floor. The channel is straight above the station for about 0 feet and below for a distance of 500 feet. The current is swift, e banks high and rocky, with a rocky and permanent stream bed. ıe gage is read twice daily, 7 a. m. and 5 p. m., by William W. Young. he drainage area of the Kennebec River at this point is 1,670 square iles. The following measurements of flow of the Kennebec at this ›int have been made by N. C. Grover and F. E. Pressey:

Discharge measurements of Kennebec River at The Forks, Me.

Date.	Hydrographer.	Gage height.	Discharge.
1901.		*Feet.*	*Sec.-ft.*
ptember 28	N. C. Grover	2.60	1,863
tober 20	do	.90	473
1902.			
pril 25	do	3.70	3,495
ıne 16	do	5.60	8,862
ıne 25	do	4.75	5,896
ptember 14	F. E. Pressey	2.10	1,475

Daily gage height, in feet, of Kennebec River at The Forks, Me.

Day.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.										
	(a)	8.60	6.85	4.10	6.00	4.50	1.95	2.05	1.10	(b)
	2.55	8.40	8.05	5.75	6.15	4.50	1.95	1.80	1.10	
	2.90	8.10	8.20	6.35	6.10	5.65	1.95	1.60	1.10	
	3.10	7.95	8.20	6.50	6.00	4.05	2.40	2.00	1.45	
	3.00	7.55	6.40	7.55	5.80	4.05	2.35	2.05	1.30	
	2.95	7.15	6.05	7.80	5.80	3.80	2.60	2.00	1.45	
	2.70	6.40	6.25	7.50	5.40	3.50	2.55	2.05	1.50	
	2.85	6.60	6.25	7.60	4.80	3.40	2.65	2.05	1.50	
	2.70	6.50	6.70	7.70	4.75	3.40	2.70	2.00	2.00	
	2.60	6.45	6.35	7.80	4.50	3.40	2.65	1.80	2.00	
	2.60	6.30	6.70	6.70	4.55	3.50	2.60	1.60	2.00	
	2.00	5.35	6.80	6.40	4.50	3.50	2.55	1.60	2.10	
	1.60	5.50	6.70	6.10	5.80	3.30	2.50	1.95	2.05	
	1.60	5.30	7.10	5.80	4.95	3.35	2.45	2.00	2.10	
	1.50	5.25	6.90	7.30	4.65	3.15	2.40	2.05	2.00	
	1.45	5.10	5.50	5.70	4.75	3.00	2.30	2.20	(b)	
	2.00	5.60	5.75	5.55	4.65	3.05	2.10	2.20		
	2.55	5.70	5.30	5.45	4.65	3.00	2.00	1.60		
	2.90	5.90	5.50	5.90	4.65	2.95	2.00	2.00		3.00
	3.80	5.85	4.50	5.90	4.65	2.75	2.00	2.10		3.00
	4.00	6.10	4.90	4.70	4.65	2.85	2.50	2.50		3.00
	4.30	6.25	4.90	5.50	4.50	2.80	2.80	2.35		3.00
	4.40	5.80	4.80	5.15	5.20	2.80	2.50	2.55		3.00
	4.30	5.05	5.00	5.20	3.80	2.80	2.05	2.45		3.00
	3.85	4.20	5.60	6.10	2.70	2.80	2.45	2.60		3.00
	3.50	3.75	6.50	5.30	2.90	2.60	2.00	2.40		3.00
	3.60	4.80	6.50	5.55	3.15	2.20	2.25	2.40		3.00
	4.00	6.05	4.50	4.45	4.25	2.00	2.15	2.55		(a)
	4.35	6.10	4.00	4.30	4.15	2.00	2.10	2.55		
	6.00	6.00	3.75	4.80	4.15	2.00	2.15	2.50		
	7.80		4.60		4.30	2.10		1.80		

a Frozen from January 1 to March 1 and December 28 to 31.
b No measurements, November 16 to December 18.

Rating table for Kennebec River at The Forks, Me., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.0	560	3.2	2,635	5.4	8,000	7.6	16,80
1.2	720	3.4	2,950	5.6	8,800	7.8	17,60
1.4	880	3.6	3,310	5.8	9,600	8.0	18,40
1.6	1,040	3.8	3,700	6.0	10,400	8.5	20,40
1.8	1,200	4.0	4,120	6.2	11,200	9.0	22,40
2.0	1,365	4.2	4,560	6.4	12,000	9.5	24,40
2.2	1,525	4.4	5,020	6.6	12,800	10.0	26,40
2.4	1,700	4.6	5,510	6.8	13,600	10.5	28,40
2.6	1,900	4.8	6,040	7.0	14,400	11.0	30,40
2.8	2,105	5.0	6,620	7.2	15,200	11.5	32,40
3.0	2,350	5.2	7,270	7.4	16,000	12.0	34,40

Estimated monthly discharge of Kennebec River at The Forks, Me.

[Drainage area, 1,670 square miles.]

Month.	Discharge in second-feet.			Run-off
	Maximum.	Minimum.	Mean.	Second-feet per square mile.
1901.				
October	2,350	480	1,585	0.95
November	1,900	1,120	1,442	0.86
December 8 to 19			[b]8,498	[b]5.09
1902.				
March [a]	17,600	920	3,336	2.00
April	20,800	3,600	11,109	6.65
May	19,200	3,600	10,531	6.31
June	17,600	4,330	10,628	6.36
July	11,000	2,000	6,285	3.76
August	9,000	1,365	2,875	1.72
September	2,105	1,325	1,651	0.99
October	1,900	1,040	1,461	0.87
November 1 to 15	1,445	640	[b]1,082	[b]0.65
December 19 to 27	2,350	2,350	[b]2,350	[b]1.41

[a] Frozen during January and February. [b] Partial month

KENNEBEC RIVER AT NORTH ANSON, ME.

This station was established on October 18, 1901, by N. C. Grover. It is located 1½ miles east of North Anson, and is reached by private conveyance. Measurements are made from the bridge across the

ennebec. The gage is a vertical rod graduated to feet and tenths id fastened to the bridge pier. It is referred to two bench marks, ie being the top of pier back of gage, elevation 22.5 feet, and the her the top of the southeast corner of the twelfth stone from the p of west abutment, elevation 9.55 feet above the zero of the gage. he initial point of soundings is on the left bank at the outside of the id post of the bridge. The channel is straight above the station for)0 feet, and below for 1,000 feet. The current is swift, the right ink high and rocky, while the left bank is comparatively low and ibject to overflow at the time of highest water. The bed of the ream is rocky, with sand over a portion of the section. The gage is ad twice daily, at 8 a. m. and 4 p. m., by C. S. Benjamin, the toll)llector at the bridge. The drainage area is 2,880 square miles. he following measurements have been made by N. C. Grover and . E. Pressey:

October 14, 1901: Gage height, 3.2 feet; discharge, 3,114 second-feet.
October 18, 1901: Gage height, 3.0 feet; discharge, 2,458 second-feet.
July 29, 1902: Gage height, 4.55 feet; discharge, 6,224 second-feet.

Daily gage height, in feet, of Kennebec River at North Anson, Me.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.										
.....	(a)	12.65	10.75	6.95	6.10	4.10	3.25	3.15	5.10	3.25
.....	.....	11.70	10.45	6.70	5.85	4.50	3.85	3.25	3.95	3.40
.....	.....	10.75	11.30	6.10	5.85	5.30	3.15	3.00	3.50	3.50
.....	.....	9.00	9.90	7.40	5.60	4.85	3.00	2.95	3.25	3.45
.....	.....	7.90	7.55	8.75	5.45	4.50	3.45	2.90	3.10	3.35
.....	.....	7.00	7.25	8.90	5.35	4.15	3.35	3.10	3.15	(a)
.....	.....	7.15	7.55	8.95	5.05	4.20	3.20	3.25	3.10	.....
.....	.....	7.20	8.60	8.60	5.00	4.15	3.45	3.45	3.05	.....
.....	.....	7.45	8.15	9.90	4.80	4.25	3.35	3.30	3.05	.....
.....	.....	7.00	7.90	9.25	4.85	4.20	3.75	2.90	3.20	.....
.....	.....	6.90	6.45	8.30	5.00	4.20	3.95	2.80	3.05	.....
.....	.....	6.85	7.45	7.65	5.00	4.40	3.65	2.65	2.95	.....
.....	.....	6.75	6.95	6.70	5.05	4.15	3.40	2.90	3.20	.....
.....	.....	6.30	6.95	6.45	4.90	3.70	3.80	3.05	3.35	.....
.....	.....	6.50	5.95	6.30	4.90	3.60	4.10	3.15	3.60	.....
.....	.....	6.85	5.80	6.10	5.05	3.65	3.95	3.40	3.85	.....
.....	.....	6.75	5.75	6.20	5.10	3.20	3.50	3.20	4.05	.....
.....	.....	6.05	5.75	6.25	5.20	3.00	3.10	3.10	4.10	.....
.....	.....	6.80	5.35	5.65	5.10	2.55	3.05	3.05	4.00	.....
.....	.....	6.35	5.15	5.55	5.30	2.70	3.25	3.70	3.85	.....
.....	.....	7.35	5.35	5.20	5.55	3.20	4.00	3.65	3.85	.....
.....	.....	7.15	5.55	5.65	5.55	3.15	4.25	3.95	3.85	.....
.....	11.30	7.55	5.80	5.55	5.25	3.80	4.00	3.90	3.70	.....
.....	8.75	7.30	5.90	6.10	5.25	4.15	3.90	3.65	3.80	.....
.....	7.75	6.30	5.80	5.65	5.05	4.15	3.30	3.50	3.65	.....
.....	6.75	6.55	6.65	6.75	5.05	3.65	3.00	3.00	3.45	.....
.....	6.05	6.55	7.65	7.45	5.00	3.25	3.00	2.95	3.40	.....
.....	5.75	6.85	8.25	6.60	4.65	3.15	3.05	3.65	3.15	.....
.....	7.55	7.10	9.25	5.95	4.40	3.00	3.20	5.95	3.15	.....
.....	11.60	7.65	7.55	5.70	4.45	2.85	3.15	5.85	3.15	.....
.....	11.35	.....	7.30	.....	4.25	2.95	.....	5.80	.....	.....

a Frozen January 1 to March 22 and December 6 to 31.

KENNEBEC RIVER AT WATERVILLE, ME.

The only long-continued observations of the volume of the river are those which have been made at Waterville by the Hollingsworth & Whitney Company, which kindly furnished the results for publication herein. The works of that company are above the mouth of Sebasticook River. The tributary drainage area of the Kennebec at this point is about 4,380 square miles. The figures really represent the flow at 12 o'clock noon of each day, that hour having been chosen after investigation, as a time when the flow is least affected by storage at dams upstream, and as giving most nearly the average for the day.

A summary of these results, including 1900, will be found in Water-Supply Paper, No. 69. The following tables give the results for 1901 and 1902:

Daily discharge, in second-feet, of Kennebec River at Waterville, Me.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	De.
1901.												
1	3,740	2,990	2,050	11,000	29,600	5,140	9,080	6,480	1,470	2,770	3,7[illegible]	[illegible]
2	3,530	2,920	2,270	15,200	30,570	6,540	8,350	5,270	4,760	2,160	3,0[illegible]	[illegible]
3	3,240	2,180	1,620	19,580	29,620	8,700	8,330	4,810	4,270	1,580	4[illegible]	[illegible]
4	2,990	2,690	2,840	25,040	28,080	12,930	4,620	2,410	3,910	2,140	3,0[illegible]	[illegible]
5	2,420	2,680	4,080	54,490	23,350	11,380	7,940	3,890	3,640	2,730	3,6[illegible]	[illegible]
6	1,880	2,670	4,290	57,960	21,380	9,900	7,330	3,170	3,630	980	3,0[illegible]	[illegible]
7	3,100	2,700	4,350	42,370	13,300	9,110	5,110	3,290	3,040	3,090	3,3[illegible]	[illegible]
8	3,280	3,000	4,220	76,410	11,800	9,930	5,130	5,830	1,140	2,460	2,8[illegible]	[illegible]
9	3,220	2,420	4,130	76,590	13,290	15,250	6,020	6,180	2,870	2,740	2,5[illegible]	[illegible]
10	3,040	2,000	2,870	60,700	12,340	13,900	5,770	5,640	3,120	2,390	5[illegible]	[illegible]
11	3,240	2,680	4,090	53,410	16,330	10,000	5,750	3,240	2,790	2,470	2,6[illegible]	[illegible]
12	3,240	2,690	4,010	39,290	22,880	10,120	5,450	5,640	3,070	2,380	2,2[illegible]	[illegible]
13	2,780	2,690	3,970	35,610	23,110	7,830	5,440	5,920	3,650	670	2,2[illegible]	[illegible]
14	3,230	2,660	4,060	33,250	21,770	7,830	3,310	5,410	3,700	3,050	2,9[illegible]	[illegible]
15	2,940	2,340	3,390	31,460	18,120	7,470	4,860	5,010	1,700	6,430	1,6[illegible]	[illegible]
16	3,430	2,350	3,410	30,220	14,230	5,660	4,600	3,840	3,370	6,680	2,2[illegible]	[illegible]
17	3,530	2,000	3,080	29,300	14,210	7,840	4,450	5,640	3,090	5,060	1,3[illegible]	[illegible]
18	3,960	2,900	3,700	28,820	12,110	6,640	4,400	4,630	2,830	4,360	2,8[illegible]	[illegible]
19	4,040	2,640	3,440	29,150	10,450	7,170	4,450	4,700	1,910	4,230	2,5[illegible]	[illegible]
20	2,840	2,650	3,110	27,600	14,560	6,630	4,840	4,080	2,800	1,870	2,5[illegible]	[illegible]
21	3,250	2,670	3,640	28,540	11,990	6,290	4,010	3,900	2,560	2,810	2,5[illegible]	[illegible]
22	3,490	2,380	4,180	45,590	7,560	6,420	4,220	3,650	750	2,830	2,3[illegible]	[illegible]
23	3,500	2,390	5,050	65,770	9,860	5,630	3,940	3,120	3,160	2,340	2,2[illegible]	[illegible]
24	3,520	1,430	700	65,970	7,600	6,960	3,480	3,800	3,190	2,920	1,4[illegible]	[illegible]
25	3,230	2,140	8,510	49,700	7,590	6,020	3,400	3,530	2,800	2,960	2,4[illegible]	[illegible]
26	3,260	2,320	8,500	44,710	6,620	6,880	3,720	4,100	2,810	3,720	2,3[illegible]	[illegible]
27	2,380	2,530	12,890	42,510	9,090	6,970	3,810	3,900	2,420	1,280	2,3[illegible]	[illegible]
28	2,990	1,990	10,530	39,950	8,260	7,050	2,810	2,880	2,380	3,100	2,0[illegible]	[illegible]
29	3,200	.....	13,340	38,280	9,060	6,980	4,510	1,890	790	2,840	2,3[illegible]	[illegible]
30	2,950	.....	8,440	34,780	5,140	7,800	4,520	1,840	3,010	2,790	2,4[illegible]	[illegible]
31	2,970	.....	4,120	.....	6,420	.....	5,740	1,850	.....	2,850	.....	[illegible]

ily discharge, in second-feet, of Kennebec River at Waterville, Me.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	4,610	4,020	11,790	47,870	34,410	15,370	12,200	4,990	3,190	4,080	8,020	4,100
	4,280	2,670	23,180	37,920	28,840	15,350	12,670	5,370	4,120	4,120	5,980	4,080
	3,960	4,100	35,110	36,530	28,890	13,050	13,200	4,630	4,080	4,110	5,670	4,090
	3,150	3,840	54,340	29,290	26,340	12,500	10,310	9,010	3,280	4,080	4,830	4,070
	900	3,850	38,050	25,220	19,740	17,860	10,990	7,480	3,740	2,020	3,760	3,390
	3,460	3,980	30,250	19,460	17,210	19,750	9,890	6,490	4,090	3,510	4,130	4,070
	3,730	4,010	25,920	21,340	17,860	19,140	10,470	5,320	1,580	4,170	4,220	1,020
	3,490	4,010	22,280	21,200	24,290	16,830	9,850	5,130	3,500	5,550	4,080	3,710
	2,960	2,850	20,240	20,020	20,720	26,140	8,880	5,240	4,040	4,160	3,040	3,190
	3,280	3,990	17,740	24,790	17,520	24,550	8,910	4,420	4,000	4,160	4,120	3,580
	3,760	3,970	20,940	23,370	15,730	20,390	9,510	5,090	7,540	3,770	4,080	2,900
	2,240	3,910	13,160	23,470	13,090	16,510	9,410	5,730	5,850	1,750	4,100	4,090
	3,840	3,910	14,230	21,340	13,490	14,760	7,290	5,850	5,390	3,510	4,020	3,990
	3,410	3,940	17,590	21,290	13,600	13,040	5,440	5,180	3,430	3,780	4,180	2,350
	2,890	3,950	18,940	16,970	10,480	11,700	6,940	3,860	7,570	3,730	4,380	3,990
	3,210	2,100	18,860	18,730	10,530	11,210	7,840	3,980	5,860	4,080	4,550	3,970
	3,180	3,950	27,940	17,540	9,720	11,340	7,200	1,890	5,180	4,120	5,450	6,930
	3,160	3,370	46,630	16,940	8,410	11,590	6,920	3,740	4,140	4,080	5,420	5,150
	1,790	3,930	22,400	17,500	5,560	10,670	6,940	3,440	4,100	2,080	5,040	5,480
	3,550	3,660	27,320	17,880	8,420	10,550	5,740	2,640	4,100	4,200	4,920	4,900
	2,870	3,440	46,570	18,740	9,640	9,710	6,780	2,300	2,410	4,980	4,680	3,420
	2,860	3,660	45,320	21,250	8,950	8,400	7,010	3,320	4,730	4,510	4,380	4,710
	7,810	3,150	46,670	24,080	12,320	13,110	6,940	5,950	4,580	4,560	4,470	6,220
	10,510	4,080	36,990	21,290	8,990	10,620	6,460	12,670	4,180	4,200	4,600	6,900
	6,360	4,100	27,490	17,640	13,080	10,160	6,230	8,250	3,990	4,130	4,160	5,480
	4,620	4,840	22,900	13,910	13,560	10,200	4,870	6,590	3,820	2,730	4,300	5,160
	4,070	4,420	18,720	13,430	21,690	33,940	4,500	4,080	4,020	3,950	3,450	5,150
	3,870	4,700	13,920	18,620	23,800	21,870	5,100	4,130	2,060	7,830	4,200	4,660
	3,880	.....	20,670	19,500	29,210	15,370	5,170	4,150	3,950	24,980	4,140	5,000
	3,910	.....	57,970	18,000	19,250	12,130	4,950	4,040	4,100	15,170	3,130	4,540
	3,940	.....	47,070	.....	17,820	.....	4,950	1,860	.....	10,830	.....	4,450

Estimated monthly discharge of Kennebec River at Waterville, Me.

[Drainage area, 4,380 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1901.					
anuary	4,040	1,880	3,176	0.73	0.84
'ebruary	3,000	1,430	2,489	.57	.59
larch	13,340	700	4,805	1.10	1.27
April	76,590	11,600	41,130	9.39	10.47
lay	30,570	5,140	15,169	3.46	3.99
une	15,250	5,140	8,235	1.88	2.10
uly	9,080	2,810	5,122	1.17	1.35
ugust	6,480	1,840	4,178	.95	1.10

Estimated monthly discharge of Kennebec River at Waterville, Me.—Continued.

Month.	Discharge in second-feet.			Run-off
	Maximum.	Minimum.	Mean.	Second-feet per square mile.
1901.				
September	4,760	750	2,821	.64
October	6,680	670	2,925	.67
November	3,710	480	2,405	.55
December	46,750	170	7,527	1.72
The year	76,590	170	8,332	1.90
1902.				
January	10,510	900	3,856	.88
February	4,840	2,100	3,800	.87
March	57,970	11,790	28,768	6.57
April	47,870	13,430	22,191	5.07
May	34,410	5,560	16,873	3.85
June	33,940	8,400	15,260	3.48
July	13,200	4,500	7,840	1.79
August	12,670	1,860	5,057	1.15
September	7,570	1,580	4,218	.96
October	24,980	1,750	5,255	1.20
November	8,020	3,040	4,517	1.03
December	6,930	1,020	4,346	.99
The year	57,970	900	10,165	2.32

CARRABASSETT RIVER NEAR NORTH ANSON, ME.

This river enters the Kennebec from the west at North Anson. Its basin has steep slopes, partly in farm lands, with no large natural reservoirs. Dams have been constructed and power used at North Portland, East New Portland, and North Anson. On October 1, 1901, a gaging station was established on the Carrabassett, 1 mile west of North Anson, by N. C. Grover. The station is located above Embden Brook and below Anson Brook. The drainage area is 1,100 square miles at this point. The gaging is made from a boat held in position by a manila rope stretched across the stream. The gage is a vertical rod graduated to feet and tenths, and referred to a bench mark on a blazed spruce tree 40 feet from the gage. The elevation of bench mark is 10.78 feet above the zero of the gage. The gage is read every morning by N. Q. Hilton, a farmer in North Anson.

Discharge measurements of Carrabassett River near North Anson, Me.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Sec.-ft.*
ne 27	N. C. Grover	4.3	4,168
ly 30	F. E. Pressey	0.6	192
tober 30	do	2.48	1,812
Do	do	2.68	2,120
tober 31	do	2.00	1,369
ovember 1	do	1.69	1,129
Do	do	1.60	1,083
ovember 2	do	1.42	882
ovember 3	do	1.35	851

Daily gage height, in feet, of Carrabassett River near North Anson, Me.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.							
		1.40	0.40	0.70	0.90	1.70	1.00
		1.80	.40	.80	1.10	1.50	1.00
		1.60	1.50	.70	1.00	1.40	.90
		1.50	1.20	.70	.90	1.30	1.00
		1.30	1.00	.90	.80	1.20	1.10
		1.10	.90	.80	1.20	1.10	1.10
		1.00	.80	.70	1.70	1.10	1.20
		.90	.80	.90	1.30	1.10	1.20
		.80	.80	.80	1.10	1.10	1.10
		.80	.80	2.80	1.10	1.00	1.10
		.90	.70	1.90	1.00	1.00	1.10
2		.70	.90	1.40	.90	1.00	.90
3		.70	.90	1.20	.90	1.10	1.10
4		.60	.70	2.80	.90	1.10	(a)
5		.60	.60	2.10	1.00	1.40	
6		.60	.50	1.60	.90	1.50	
7		.60	.50	1.30	.80	1.50	
8		.50	.50	1.10	.80	1.30	
9		.50	.50	1.00	.80	1.20	
0		.60	.30	1.40	1.40	1.20	
1		.60	.30	1.10	1.60	1.20	
2		1.00	.30	1.10	1.30	1.10	
3		1.00	6.40	1.00	1.10	1.20	
4		.80	3.60	1.10	1.10	1.10	
5		.80	2.30	.90	.90	1.10	
6	4.80	.70	1.60	.80	1.00	1.00	
7	4.90	.60	1.40	.80	.90	1.00	
8	3.10	.60	1.10	.80	1.50	1.10	
9	2.20	.60	1.00	1.00	4.30	1.00	
0	1.70	.50	.80	1.00	2.50	1.00	
1		.50	.70		2.00		

a Frozen December 14 to 31.

Rating table for Carrabassett River near North Anson, Me., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.4	70	1.8	1,235	3.2	2,665	4.6	4,565
.6	192	2.0	1,400	3.4	2,935	4.8	4,840
.8	365	2.2	1,575	3.6	3,210	5.0	5,100
1.0	540	2.4	1,750	3.8	3,480		
1.2	715	2.6	1,950	4.0	3,755		
1.4	885	2.8	2,160	4.2	4,030		
1.6	1,060	3.0	2,400	4.4	4,300		

Estimated monthly discharge of Carrabassett River near North Anson, Me.

[Drainage area, 340 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
June 26 to 30			[b]3,012	[b]8.86	[b]1.65
July	1,235	130	408	1.20	1.38
August	6,920	45	713	2.10	2.42
September	2,160	275	716	2.11	2.35
October	1,850	365	763	2.24	2.58
November	1,145	540	703	2.07	2.31
December 1 to 13 [a]	715	450	[b]595	[b]1.75	[b]1.95

[a] Gage frozen remainder of month.

[b] Partial month.

DEAD RIVER NEAR THE FORKS, ME.

This tributary of the Kennebec has its headwaters in the mountains between Maine and Canada and flows in a general easterly direction, entering the Kennebec at The Forks. Its basin contains 870 square miles and is 40 miles in extreme length by 30 in width and almost wholly wooded. Through a large portion of its length the river flows through swamps; in its lower course it has considerable fall. The only dams on the stream are owned by the log-driving companies, and the gates are kept open after the drive is out of the river. A gaging station was established on Dead River near The Forks on September 29, 1901, by N. C. Grover. The station is 1½ miles west of The Forks and is reached by private conveyance. The measurements are made from a car suspended from a steel cable. There are two gages, one on either bank. The gage on the right bank is a vertical rod gage

ated to feet and tenths and referred to two bench marks. One is on he right bank on the top of large bowlder at end of wharf on which age is placed; its elevation is 4.48 feet above the zero of the gage. The other is on the left bank, 200 feet above the gage, on the top of owlder; its elevation is 10.89 feet. The gage on the left bank is an nclined rod graduated to feet and tenths of vertical elevation, and eferred to one bench mark marked by a cross on a granite bowlder ear the gage; its elevation is 5.55 feet above the zero of the gage. The channel is straight for 500 feet above and below the cable, the urrent swift. The banks are rocky, though subject to overflow at he time of highest water. The bed is rocky and permanent. The age is read twice daily, 6 a. m. and 6 p. m., by Jeremiah Durgin, jr., farmer at The Forks.

The following discharge measurement was made during the year 901 by N. C. Grover:

September 29; Gage height, 0.40 foot; discharge, 225 second-feet.

Daily gage height, in feet, of Dead River near The Forks, Me.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.							
1		2.57	2.35	0.80	1.00	2.40	1.00
2		2.10	2.25	.90	1.00	1.15	1.00
3		1.85	2.20	1.00	.90	1.75	1.20
4		1.55	1.95	1.10	.90	1.75	1.20
5		1.70	1.80	1.15	1.00	1.55	1.10
6		1.50	1.60	1.00	.90	1.45	1.00
7		1.40	1.50	1.10	1.15	1.35	(a)
8		1.40	1.40	1.00	1.25	1.30	
9		1.30	1.40	.90	1.55	1.25	
10		1.10	1.35	1.00	1.50	1.10	
11		1.00	1.25	1.10	1.20	1.00	
12		.80	1.10	1.45	1.25	1.40	
13		1.20	1.00	1.75	1.45	1.80	
14		1.15	.90	1.80	1.60	1.90	1.10
15		1.10	.80	1.70	1.60	1.85	1.20
16		1.10	.70	1.60	1.60	1.70	1.20
17		1.10	1.10	1.50	2.00	1.90	1.10
18		1.10	1.00	1.25	1.50	1.80	1.10
19		1.10	1.00	1.00		1.60	1.20
20		1.00	1.00	1.75	1.00	1.05	1.20
21		.85	.90	1.75	1.00	1.55	1.30
22		.70	.80	1.80	.90	1.50	1.45
23		.70	.70	1.70	.90	1.50	1.50
24		.90	1.00	1.55	1.00	1.40	1.50
25	1.60	1.00	1.80	1.35	1.10	1.30	1.50
26	2.00	1.10	1.50	1.20	1.15	1.30	1.50
27	3.30	1.20	1.30	1.10	1.10	1.20	1.40
28	3.20	1.45	1.20	1.10	1.20	1.10	(a)
29	4.15	1.65	1.10	1.10	1.00	1.05	
30	3.20	2.00	1.00	1.00	1.50	1.00	
31		2.10	.90		1.85		

a Frozen December 7 to 13 and 28 to 31.

MOOSE RIVER NEAR ROCKWOOD, ME.

This station was established September 7, 1902, by N. C. Grover. It is located 4 miles west of Kineo, Me., 2 miles from the mouth of the river, and is reached by steamer on the lake and rowboat on the river. The drainage basin is 680 square miles at this point. Measurements are made from a car suspended from a steel cable. The initial point for soundings is on the right bank, 1 foot from a birch tree, to which the tag line and cable are attached. The gage is a painted post, graduated to feet and tenths, driven into the clay bed of the river, and braced from several trees. For high-water stages a gage is placed on a fir tree about 20 feet upstream from the low-water gage. The gage is read daily at 7 a. m. and 4 p. m. by Peter Callaghan. The channel, both above and below the station, is straight, the banks are high and rocky, and the bed of the stream is rocky. The bench mark is a horizontal mark on the fir tree behind and on a level with the 10-foot mark of the high-water gage.

During 1902 the following measurements were made by F. E. Pressey:

September 7: Gage height, 2.4 feet; discharge, 385 second-feet.
November 23: Gage height, 3.9 feet; discharge, 1,168 second-feet.

Daily gage height, in feet, of Moose River near Rockwood, Me., for 1902.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	.....	3.60	4.60	3.50	17	3.00	3.30	3.90	[illegible]
2	.....	3.60	4.60	3.50	18	2.90	3.25	3.90	[illegible]
3	.....	3.50	4.50	3.50	19	2.90	3.30	3.90	[illegible]
4	.....	3.45	4.40	3.40	20	3.10	3.40	3.90	[illegible]
5	.....	3.40	4.35	3.40	21	3.10	3.45	3.90	[illegible]
6	.....	3.40	4.30	3.40	22	3.30	3.45	3.90	[illegible]
7	2.40	3.40	4.20	3.35	23	3.70	3.50	3.90	[illegible]
8	2.40	3.50	4.20	3.25	24	3.80	3.50	3.90	[illegible]
9	2.40	3.50	4.05	3.15	25	3.80	3.50	3.85	[illegible]
10	2.50	3.45	4.00	3.10	26	3.80	3.45	3.80	[illegible]
11	2.50	3.40	3.90	3.00	27	3.80	3.40	3.75	[illegible]
12	2.60	3.40	3.85	2.95	28	3.75	3.50	3.70	[illegible]
13	2.60	3.30	3.80	2.90	29	3.70	4.05	3.65	[illegible]
14	2.75	3.30	3.80	2.90	30	3.70	4.45	3.60	[illegible]
15	2.85	3.30	3.80	2.80	31	.....	4.60	.....	[illegible]
16	2.90	3.30	3.80	2.80					

ROACH RIVER AT ROACH RIVER, ME.

This stream, entering Moosehead Lake from the east, rises in the highland region of Maine, its basin being well wooded and containing several ponds of considerable size. At the foot of Lower Roach Pond is a dam, owned by the log drivers, which controls the flow of the river. The drainage area of the river at this point is 85 square miles

The station at Roach River was established November 10, 1901, by N. C. Grover. It is reached by stage from Lily Bay. The gage is a vertical rod spiked to the timber retaining embankment on the right bank of the stream. It is divided into feet and tenths and referred to a bench mark, a cross on the top timber to which the gage is spiked, the elevation of this mark being 9 feet. The gage is read twice daily, at 9 a. m. and 3 p. m., by C. H. Sawyer, hotel keeper.

During 1902 the following measurements were made by F. E. Pressey:

September 2: Gage height, 2.50 feet; discharge, 112 second-feet.
September 2: Gage height, 2.70 feet; discharge, 200 second-feet.
September 2: Gage height, 2.90 feet; discharge, 286 second-feet.
September 3: Gage height, 2.30 feet; discharge, 72 second-feet.
September 3: Gage height, 2.11 feet; discharge, 32 second-feet.

Daily gage height, in feet, of Roach River at Roach River, Me.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.80	2.90	2.60	2.30	5.60	2.50	2.80	2.25	2.50	2.30	2.30	2.50
2	2.80	2.80	2.60	2.30	3.80	2.50	2.80	2.50	2.50	2.30	2.50	2.50
3	2.80	2.80	2.85	2.30	5.40	2.50	2.80	2.50	2.50	2.30	2.50	2.50
4	2.60	2.80	3.00	2.30	3.80	2.50	2.80	2.50	2.50	2.30	2.50	2.50
5	2.60	2.80	3.15	3.75	5.40	2.50	2.80	2.50	2.50	2.30	2.50	2.50
6	2.60	2.80	3.20	5.15	3.80	2.50	2.80	2.50	2.50	2.30	2.50	2.50
7	2.90	2.80	3.20	5.10	3.80	2.50	2.80	2.50	2.50	2.30	2.50	2.50
8	2.90	2.80	3.15	2.30	2.20	2.50	2.80	2.50	2.50	2.30	2.50	2.50
9	2.90	2.80	3.00	5.10	5.50	3.00	2.80	2.50	2.50	2.30	2.50	2.50
10	2.90	2.80	3.00	3.75	3.85	3.00	2.80	2.50	2.40	2.30	2.50	2.50
11	2.90	2.80	3.00	5.20	2.20	3.00	2.80	2.50	2.40	2.30	2.50	2.50
12	2.90	2.80	3.00	3.75	5.50	3.00	2.80	2.50	2.40	2.30	2.50	2.50
13	2.90	2.80	3.00	3.75	3.85	3.00	2.80	2.50	2.40	2.30	2.50	2.50
14	2.90	2.80	3.00	5.20	3.85	3.00	2.80	2.50	2.40	2.30	2.50	2.50
15	2.90	2.60	3.00	3.75	2.20	2.60	2.80	2.50	2.40	2.30	2.50	2.50
16	2.90	2.60	3.00	3.75	3.85	2.60	2.80	2.50	2.40	2.30	2.50	2.50
17	2.90	2.60	3.10	5.20	3.85	2.60	2.80	2.50	2.30	2.30	2.50	2.50
18	2.90	3.60	3.40	5.20	2.20	2.60	2.80	2.50	2.30	2.30	2.50	2.50
19	2.90	2.60	3.50	2.30	2.20	2.60	2.80	2.50	2.30	2.30	2.50	2.50
20	2.90	2.60	4.50	3.75	2.20	2.60	2.80	2.50	2.30	2.30	2.50	2.50
21	2.90	2.60	5.35	3.75	3.85	2.60	2.80	2.50	2.30	2.30	2.50	2.50
22	2.90	2.60	4.00	4.90	3.85	2.80	2.80	2.50	2.30	2.30	2.50	2.50
23	3.10	2.60	4.90	4.90	2.20	2.80	2.80	2.50	2.30	2.30	2.50	2.50
24	3.00	2.60	3.95	5.30	5.50	2.80	2.80	2.50	2.30	2.30	2.50	2.50
25	2.90	2.60	4.20	5.25	5.50	2.80	2.80	2.50	2.30	2.30	2.50	2.20
26	2.90	2.60	3.90	5.10	5.50	2.80	2.80	2.50	2.30	2.30	2.50	2.20
27	2.90	2.60	2.70	2.30	5.50	2.80	2.80	2.50	2.30	2.30	2.50	2.20
28	2.90	2.60	2.20	2.30	3.50	2.80	2.80	2.50	2.30	2.30	2.50	2.20
29	2.90	.....	2.25	4.60	3.05	2.80	2.50	2.50	2.30	2.30	2.50	2.20
30	2.90	.....	2.30	4.90	2.60	2.80	2.20	2.50	2.30	2.30	2.50	2.20
31	2.90	.....	2.30	.....	2.60	.....	2.20	2.50	.....	2.30	.....	2.20

Rating table for Roach River at Roach River, Me., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet*
2.1	31	2.8	244	3.5	538	4.4	916
2.2	48	2.9	286	3.6	580	4.6	1,000
2.3	67	3.0	328	3.7	622	4.8	1,084
2.4	90	3.1	370	3.8	664	5.0	1,168
2.5	118	3.2	412	3.9	706	5.2	1,252
2.6	156	3.3	454	4.0	748	5.4	1,336
2.7	200	3.4	496	4.2	832	5.6	1,420

Estimated monthly discharge of Roach River at Roach River, Me.

[Drainage area, 85 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches
1901.					
November 10 to 30			53	0.62	0.69
December	601	67	261	3.07	3.54
1902.					
January	370	156	273	3.21	3.70
February	286	156	202	2.38	2.48
March	1,315	48	432	5.08	5.86
April	1,294	67	750	8.82	9.84
May	1,420	48	687	8.08	9.31
June	328	118	207	2.44	2.72
July	244	48	227	2.67	3.08
August	118	57	116	1.36	1.57
September	118	67	88	1.04	1.16
October	67	67	67	.79	.91
November	118	67	116	1.36	1.52
December	118	48	102	1.20	1.38
The year	1,420	48	272	3.20	43.52

COBBOSSEECONTEE RIVER AT GARDINER, ME.

Cobbosseecontee River drains a group of lakes lying from 5 to 15 miles westerly from Augusta, and empties into the Kennebec 6 miles below that city at Gardiner, its drainage area amounting to about 25

quare miles. From the ordinary surface of Lake Maranacook, one f the upper lakes, to mean tide at the mouth of the river the fall is 06 feet, and in the lower three-fourths of a mile it is said to be 136 eet. From above the uppermost of the 8 dams controlled by the Gardiner Water Power Company, which are in the latter three-fourths f a mile, the municipal water supply for Gardiner is drawn and umped by water power. Record is kept of the water pumped and f the water that passes the dam through a waste gate. The sum of hese quantities represents the yield of the drainage area at the upper am, records of which have been kept by the Gardiner Water Power ompany for a series of years, and have been furnished to the Survey y their engineer, A. H. Twombly. The record for 1902 is presented n the accompanying table. On Sundays and on legal holidays the ates are closed and no water is permitted to run unless the lakes are ull. This is a most remarkable example of the regularity of flow hat can be obtained with proper storage.

Mean daily flow, in second-feet, of Cobbosseecontee River at Gardiner, Me.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	500	463	2,400	1,803	713	0	280	280	280	280	270	270
2	348	280	2,400	1,748	713	280	280	280	280	280	0	270
3	294	280	2,222	1,593	650	280	280	0	280	280	270	270
4	280	280	1,702	1,540	566	280	20	280	280	280	270	270
5	0	280	1,583	1,390	514	280	21	280	280	0	270	270
6	280	280	1,370	1,071	465	280	0	280	280	280	270	270
7	280	280	1,165	848	415	280	280	280	0	280	270	0
8	280	280	1,017	280	393	0	280	280	280	280	270	270
9	280	280	878	280	373	280	280	280	280	280	0	270
10	280	280	878	354	506	280	280	0	280	280	270	250
11	280	280	1,065	705	280	280	280	280	280	280	270	250
12	0	280	1,114	819	280	280	280	280	280	0	270	250
13	280	280	1,214	927	280	280	0	280	280	280	270	250
14	280	280	1,267	900	280	280	280	280	0	280	270	0
15	280	280	1,017	705	280	0	280	280	280	280	270	250
16	280	280	746	584	280	280	280	280	280	270	0	250
17	280	280	833	531	280	280	280	0	280	270	270	250
18	280	280	1,423	465	0	280	280	280	280	270	270	250
19	0	280	1,267	438	280	280	280	280	280	0	270	250
20	280	280	1,531	438	280	280	0	280	280	270	270	250
21	280	280	1,765	415	280	280	280	280	0	270	270	0
22	280	280	1,702	369	280	0	280	280	280	270	270	250
23	1,642	280	1,583	369	280	280	280	280	280	270	0	256
24	1,446	280	1,478	345	280	280	280	0	280	270	270	276
25	1,097	280	1,370	313	0	280	280	280	280	270	270	40
26	924	280	1,267	313	280	280	280	280	280	0	270	290
27	752	280	1,165	94	280	280	0	280	280	270	270	264
28	776	280	1,017	367	280	280	280	280	0	270	270	264
29	719	.....	789	367	280	0	280	280	280	270	270	256
30	479	.....	1,531	350	280	280	280	280	280	270	0	250
31	479	.....	1,531	.....	280	.....	280	0	.....	270	.....	250

ANDROSCOGGIN RIVER DRAINAGE BASIN.

Androscoggin River is formed by the junction of Magalloway River and the outlet of the Umbagog-Rangeley lakes near the Maine-New Hampshire boundary line. For about 35 miles it flows southward into the State of New Hampshire, then turns abruptly to the east and flows into the State of Maine, then turns to the south and joins the Kennebec in Merrymeeting Bay. The last fall on the Androscoggin is at Brunswick, Me., above which place the drainage area is 3,470 square miles, about 80 per cent of which is in Maine. The greatest length of the basin is 110 miles, the greatest width 70 miles, while the river itself measures about 200 miles in length from the sources of Magalloway River to the coast. The following table gives the drainage areas of the river at various points, and some of its chief tributaries:

Drainage areas of Androscoggin River and principal tributaries.

River.	Locality.	Drainage area.
		Square miles.
Androscoggin	Immediately below junction of Umbagog outlet and Magalloway River, at Errol Dam.	1,[illegible]
Do	Berlin	1,[illegible]
Do	Rumford Falls	2,[illegible]
Do	Dixfield	2,[illegible]
Do	Livermore Falls	3,[illegible]
Do	Lewiston Falls	3,[illegible]
Do	Brunswick	3,[illegible]
Umbagog Outlet	Immediately above junction with Magalloway River	[illegible]
Magalloway	Mouth	[illegible]
Little Androscoggin	do	[illegible]

The lower part of the basin is hilly and moderately wooded, while the upper two-thirds is broken and mountainous, heavily timbered and with a gravelly, sandy soil. Granite, gneiss, and mica-schist abound along the main course of the river, with clay slate in the upper part of the basin. The river, like others on the southern slopes of Maine, generally has a rocky bed, particularly where falls occur, has high banks, and is seldom subject to overflow, all of which are features of advantage in the development of water power. Below Berlin the stream is nowhere more than 10 miles from a railroad, and for considerable portions of its course it is immediately

rted by railroads. Tide-water navigation extends about 6 miles ve the mouth, or to the falls at Brunswick.

ANDROSCOGGIN RIVER AT DIXFIELD, ME.

This station was established August 22, 1902, by F. E. Pressey. s located about one-half mile west of Dixfield, Me., at the highway dge on the road between Dixfield and West Peru. The measurements are taken from this bridge, and the initial point for soundings at the lower end of the inclined end-post on the left bank of the er. The gage is of the usual wire type; the scale board is gradued to feet and tenths, and is nailed to the guard timber of the lower e of the bridge. The gage is read daily at 7 a. m. and 5 p. m. by F. Robinson. The channel at this point is about 600 feet wide; e current is swift in the left half and sluggish in the right half. e bed of the stream is rocky in the left half and sandy in the right lf. The bench mark is located on the north abutment at the southst corner of the bridge seat and has an elevation of 24.77 feet above e zero of the gage.

During 1902 the following measurements were made by F. E. essey:

August 23: Gage height, 8.85 feet; discharge, 4,665 second-feet.
September 18: Gage height, 8.33 feet; discharge, 3,013 second-feet.

Daily gage height, in feet, of Androscoggin River at Dixfield, Me., for 1902.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
.....	.....	7.55	8.60	9.55	8.55	17.....	.....	8.35	8.05	8.95	(a)
.....	.....	8.15	8.60	9.35	8.50	18.....	.....	8.35	8.00	8.90	.....
.....	.....	7.95	8.65	9.20	8.50	19.....	.....	8.20	8.10	8.90	.....
.....	.....	7.90	8.45	9.00	8.45	20.....	.....	8.65	8.10	8.95	.....
.....	.....	8.00	8.55	8.85	8.40	21.....	.....	8.55	8.65	8.90	.....
.....	.....	8.05	8.30	8.70	7.70	22.....	8.25	8.45	8.45	8.90	.....
.....	.....	8.15	8.85	8.70	8.05	23.....	9.05	8.35	8.30	8.95	.....
.....	.....	8.15	8.50	8.60	8.55	24.....	9.40	8.40	8.30	8.85	.....
.....	.....	8.10	8.25	8.70	(a)	25.....	8.90	8.40	8.25	8.75	.....
.....	.....	9.00	8.10	8.50	.....	26.....	8.55	8.25	8.40	8.70	.....
.....	.....	9.05	8.15	8.50	.....	27.....	8.45	8.40	8.15	8.70	.....
.....	.....	8.60	8.05	8.50	.....	28.....	8.30	8.50	9.45	8.65	.....
.....	.....	8.40	7.75	8.65	.....	29.....	8.25	8.60	11.35	8.50	.....
.....	.....	9.10	8.25	8.80	.....	30.....	8.15	8.60	9.95	8.70	.....
.....	.....	8.85	8.20	8.90	.....	31.....	8.10	.....	9.70	.....	.....
.....	.....	8.55	8.15	8.95	.....						

a Frozen December 9 to 31.

ANDROSCOGGIN RIVER AT ERROL DAM, NEW HAMPSHIRE.

Errol dam on the Androscoggin River is the last one of the series of storage dams in the Rangeley Lakes. It is below the mouth of the Magalloway, and consequently stores the flow of that river in Umbagog Lake. The total run-off from the basins of the Magalloway and of

the Umbagog-Rangeley system must pass through this dam. The basins aggregate 1,090 square miles in area. The United States Geological Survey cooperating with Walter H. Sawyer, agent for the Union Water Power Company, of Lewiston, Me., has begun a series of measurements of the flow through the gates at Errol dam. Thirteen measurements of the flow at different gate openings have been made, but the results are not yet available for publication. A continuous record of gate opening is kept, and when a sufficient number of measurements have been made to give a rating for the gates a constant record of flow will be available.

ANDROSCOGGIN RIVER AT RUMFORD FALLS, ME.

At Rumford Falls there is one of the finest water powers on the Atlantic coast. Here the Androscoggin descends 177 feet in 1 mile in several pitches over granite ledges. A comprehensive plan of development has been laid out and partially executed. It contemplates the use of power from three levels—a high-level canal, with a fall of 97 feet, to the middle level, the latter receiving also a direct and independent supply of water from the river, the water to be used from the middle-level canal and discharged, after a fall of 34 feet, into the low level, from which in turn there is a final drop of 36 feet to the river. Dams have been built at the entrance of the high and middle level canals. Water for power was first used in important amounts in the summer of 1893, and its use increased from time to time, so that at present about 19,000 horsepower is in use, the greater part being utilized in the manufacture of pulp and paper. If the entire fall of 177 feet were utilized there would be available, at Rumford Falls, from 30,000 to 54,000 horsepower. This power is sold by rail, from Portland, and for pulp and paper manufacture has the advantage of excellent transportation facilities—Androscoggin River for floating down pulp wood and timber from the headwaters to the mills, and the Rumford Falls and Rangeley Lakes Railroad, extending into the forests, with a contemplated extension into the Megantic region which will make available additional spruce, poplar, and birch forests. Altogether Rumford Falls possesses the greatest water power in the New England States. Much of it is now unutilized, but it is likely that before long the city of Rumford Falls will be a great manufacturing center.

The discharge of the Androscoggin River at Rumford Falls in 1892 has been computed by Charles A. Mixer, resident engineer for the Rumford Falls Power Company. These figures are obtained by adding the actual measured quantities passing through the wheels to the computed flow over the dam, using the customary Francis weir formula, and they have been published from time to time by the Survey, and a complete record up to 1902 will be found in Water-Supply Paper No. 69.

The following table gives the record for the year 1902:

Daily flow, in second-feet, of Androscoggin River at Rumford Falls, Me.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
.....	2,084	2,523	6,123	14,078	14,580	9,828	4,170	2,766	1,772	3,005	4,552	2,636
.....	1,925	2,103	10,482	12,290	13,521	9,801	4,398	4,618	1,781	3,174	3,880	2,005
.....	2,137	2,116	17,245	10,544	14,006	9,360	4,243	4,379	1,713	2,871	3,731	2,000
.....	2,131	2,095	10,727	8,627	11,852	9,014	4,243	3,715	1,711	2,549	3,278	2,283
.....	2,235	2,068	6,218	7,066	11,557	8,651	4,107	3,134	1,798	2,519	3,119	1,985
.....	2,191	2,043	4,593	6,186	11,281	8,298	3,882	2,757	1,882	2,575	2,797	1,618
.....	2,195	2,004	3,858	6,169	11,304	7,507	3,625	3,045	1,937	3,072	2,709	1,671
.....	2,117	2,044	3,787	5,817	11,155	7,934	3,507	3,198	2,056	2,424	2,728	1,659
.....	2,120	2,326	3,633	6,588	10,107	9,202	3,127	3,267	2,028	2,054	2,649	1,731
.....	2,019	1,979	3,285	9,980	8,840	8,266	2,974	3,080	3,537	1,905	2,649	1,902
.....	2,087	1,939	3,165	7,997	7,483	7,206	2,825	3,101	2,947	1,973	2,669	2,004
.....	2,031	1,787	3,026	6,850	7,187	6,478	2,427	3,537	2,690	1,921	2,578	2,111
.....	2,023	1,793	6,512	5,900	6,662	6,764	1,965	3,476	2,550	1,940	2,807	1,952
.....	1,837	1,776	8,528	5,928	5,177	6,992	2,239	2,909	3,385	2,256	2,923	1,750
.....	1,716	1,694	6,482	5,401	4,362	6,619	2,352	2,903	3,184	2,000	3,186	2,049
.....	1,769	1,690	5,004	5,059	3,884	6,669	2,379	2,682	2,698	1,939	2,971	2,063
.....	1,997	1,644	11,173	4,948	3,851	7,385	2,371	2,506	2,439	1,853	3,385	2,565
.....	2,288	1,726	11,690	6,431	3,215	6,357	2,222	2,630	2,261	1,870	3,179	3,083
.....	1,962	1,845	7,501	5,778	3,630	4,866	2,163	2,326	2,230	1,958	3,236	2,816
.....	1,802	2,135	7,656	5,978	3,583	4,349	1,662	2,382	2,730	2,224	3,267	2,612
.....	1,900	2,524	11,126	6,142	3,485	4,265	2,174	2,402	2,534	2,792	3,213	2,055
.....	2,646	1,960	12,663	6,700	3,700	4,637	2,734	2,682	2,585	2,451	3,137	2,821
.....	8,146	1,819	12,853	7,693	3,852	4,709	3,488	3,935	2,398	2,755	2,936	3,540
.....	5,714	1,952	11,479	10,266	4,417	4,068	3,657	3,445	2,372	2,243	3,083	3,277
.....	3,835	2,574	8,775	7,080	6,356	3,934	2,996	3,302	2,221	2,147	2,853	2,424
.....	3,157	2,436	7,961	7,716	7,645	5,417	2,533	2,741	2,465	2,010	2,789	2,506
.....	2,883	2,405	7,774	10,071	9,808	6,987	2,461	2,625	2,559	1,979	2,818	2,630
.....	2,718	2,479	8,348	10,303	17,535	5,567	2,133	2,575	2,731	6,996	2,794	2,277
.....	2,366	.....	13,178	9,555	15,684	3,573	2,292	2,226	3,002	8,336	2,576	2,294
.....	2,474	.....	18,486	13,493	12,077	3,052	2,212	2,013	2,829	5,415	2,414	2,444
.....	2,722	.....	15,673	.....	9,847	.....	2,195	1,855	.....	5,113	.....	2,322

Estimated monthly discharge of Androscoggin River at Rumford Falls, Me.

[Drainage area, 2,090 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	8,146	1,716	2,551	1.22	1.41
February	2,574	1,644	2,053	0.98	1.02
March	18,486	3,165	8,718	4.17	4.81
April	14,078	4,948	7,888	3.77	4.21
May	17,535	3,215	8,440	4.04	4.66
June	9,828	3,052	6,604	3.16	3.53
July	4,398	1,662	2,895	1.39	1.60
August	4,618	1,855	2,973	1.42	1.64
September	3,537	1,711	2,438	1.17	1.31
October	8,336	1,853	2,835	1.36	1.57
November	4,552	2,414	3,031	1.45	1.62
December	3,540	1,580	2,329	1.11	1.28
The year	18,486	1,580	4,396	2.10	28.66

PRESUMPSCOT RIVER.

This is one of the most interesting as well as one of the best water-power streams of its size in the United States. It is the outlet of Sebago Lake, which lies about 17 miles northwest of Portland. The lake is fed by Crooked River, a stream heading 35 miles farther north and within 3 miles of the Androscoggin. The area of the lake is 5 square miles, the area of its drainage basin at the outlet of the lake 420 square miles, and the total drainage area of the river at its mouth 600 square miles. The northern part of the basin is mountainous and wooded, while the southern part is moderately hilly and cleared of trees. Granite, gneiss, and mica-schists appear at many points and the soil is gravelly and sandy.

According to the survey made by Joseph A. Warren, of Cumberland Mills, the fall from the crest of the stone dam at the foot of Sebago Lake to mean low tide at the foot of the lower falls is 2[illegible] feet in a distance of 21.65 miles, or an average of 12.25 feet a mile. In the lower two-thirds of this distance, or from Gambo Falls to tide water, nearly one-half of the whole fall, or 132 feet, has been improved and an aggregate probably exceeding 6,000 net horsepower is in use. The remainder of the fall, however, between Gambo Falls and Sebago Lake, amounting to 133 feet, is either unimproved or but slightly utilized. At Great Falls, in this stretch, there is a descent of 22 feet which has been used in the past but is now idle. It is proposed, however, to employ the power in the generation of electricity for delivery in Portland.

The tributaries of Presumpscot River are not of much importance, but some of them are outlets of ponds and have considerable fall, thus affording constant though small power. Crooked River, the chief feeder of Sebago Lake, has a number of falls, some of which are utilized.

The chief interest attaching to the river is its regularity of flow, which is due to dams at the outlet of the lake. Nowhere in the United States is there a better example of the success of storage of water and regulation of the flow of a stream than on the Presumpscot. Since January, 1887, the flow from Sebago Lake has been regularly recorded, the quantity being deduced from the openings in the gates at the dam, the discharging capacity of which under different conditions of head has been determined and tabulated by Hiram F. Mills, of Lowell. Since January, 1872, a continuous record of the level of the lake surface has been kept. An unusually complete and valuable series of data has thus been obtained, which has been furnished to the United States Geological Survey by S. D. Warren & Co. The lake fills rapidly after the first of March, attaining its maximum height between the middle of April and the first of June, and then

lually subsides as water is withdrawn for mill purposes, until a imum stage is reached, sometimes in the autumn, but usually in winter. The records of the daily discharge of the river at the let of the lake, published in Water-Supply Paper No. 69, show the arkable uniformity of flow, which, as already stated, is due largely rtificial regulation. There is no other river in the United States n which so small variations occur thoughout the year. On Sun- s the gates are closed, so that only the waste is allowed to reach river.

he following table gives the record for the year 1902:

n daily flow, in second-feet, of Presumpscot River at outlet of Sebago Lake.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	627	743	667	1,733	2,080	667	583	667	733	667	775	747
	627	133	167	1,733	2,080	583	583	667	733	667	125	747
	627	650	337	1,733	2,080	583	583	667	733	667	850	747
	627	650	673	1,733	1,920	583	583	667	733	667	850	747
	133	650	673	1,733	1,650	583	583	667	733	133	850	747
	720	650	673	1,733	1,650	583	583	667	733	450	900	747
	720	650	673	7,000	1,650	583	667	667	150	450	900	117
	720	650	673	6,670	1,650	583	667	667	733	450	900	747
	720	133	167	6,670	1,650	583	667	667	733	700	133	747
	720	747	667	6,670	1,650	583	667	667	733	700	763	747
	720	747	667	6,670	1,650	583	667	667	733	700	763	747
	133	747	515	6,170	1,200	583	667	667	733	133	763	747
	717	747	667	6,170	1,200	583	667	667	733	667	763	747
	717	747	667	5,080	1,200	583	667	667	150	667	763	117
	717	747	667	5,080	1,200	583	667	667	733	667	763	575
	717	150	667	5,080	1,200	583	667	677	733	667	117	575
	717	740	680	3,680	1,200	583	667	667	733	667	757	575
	717	740	680	4,370	1,200	583	667	747	733	667	757	575
	133	667	680	4,370	667	583	667	747	733	133	757	575
	667	667	680	4,370	667	583	667	747	733	773	757	575
	667	667	680	4,100	667	583	667	747	150	773	757	117
	667	667	680	4,100	667	583	667	747	658	773	757	575
	733	150	200	4,100	667	583	667	747	658	773	125	575
	733	333	967	4,100	667	583	667	747	658	773	747	575
	733	333	967	4,100	667	583	667	733	658	773	747	575
	133	667	667	4,100	667	583	667	733	658	125	747	575
	743	667	967	4,100	667	583	667	733	658	817	747	575
	743	667	967	3,330	667	583	667	733	150	583	747	117
	743	.....	967	3,330	667	583	667	733	667	583	747	575
	743	.....	400	2,500	667	583	667	733	667	583	117	575
	743	.....	967	.....	667	.....	667	150	.....	583	.....	575

Estimated monthly discharge of Presumpscot River at outlet of Sebago Lake, Maine.

[Drainage area, 420 square miles.]

Month.	Discharge in second-feet.			Run-off.
	Maximum.	Minimum.	Mean.	Second-feet per square mile.
1902.				
January	743	133	602	1.43
February	747	133	589	1.40
March	967	167	671	1.60
April	7,000	1,733	4,205	10.01
May	2,080	667	1,186	2.82
June	667	583	586	1.40
July	667	583	651	1.55
August	747	150	681	1.62
September	733	150	636	1.51
October	817	125	598	1.42
November	900	117	675	1.61
December	747	117	582	1.39
The year	7,000	117	972	2.31

NOTE.—Minima usually occurred on Sunday.

CONNECTICUT RIVER DRAINAGE BASIN.

CONNECTICUT RIVER AT ORFORD, N. H.

This river has its source in Connecticut Lake, in the extreme northern portion of New Hampshire. A gaging and observation station was established August 6, 1900, by E. G. Paul, on the covered highway bridge over the river between Orford, N. H., and Fairlee, Vt., about 75 miles from the source of the stream. The gage for making observations of the variations in the height of water in the river consists of a scaleboard 20 feet long, graduated to feet and tenths, fastened horizontally to the inside timbers on the upper side of the bridge, 125 feet from the left-bank abutment, and a steel sash chain running over a side pulley with a 5-pound weight, the length of the chain from the extreme end of the weight to the copper rivet mark being 42.95 feet.

The observer is Frank H. Gardner, of Orford, N. H.

'he following discharge measurements were made during 1902 by arles A. Holden:

April 10: Gage height, 11.63 feet; discharge, 10,719 second-feet.
November 22: Gage height, 6.80 feet; discharge, 4,474 second-feet.

Daily gage height, in feet, of Connecticut River at Orford, N. H.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
.....	(a)	5.90	12.50	18.30	15.10	15.20	8.30	4.60	4.50	5.40	11.20	5.80
.....	.....	.....	20.30	17.65	14.90	12.10	8.10	7.30	4.40	5.20	9.80	5.80
.....	.....	.....	27.50	15.80	15.00	10.70	8.50	8.70	4.50	5.10	8.80	5.90
.....	.....	.....	25.45	13.80	14.10	12.20	8.90	9.40	4.50	4.80	8.20	5.90
.....	8.90	5.70	23.75	12.00	14.00	12.60	8.00	8.40	4.70	5.00	7.90	6.10
.....	.....	.....	21.15	11.70	10.80	11.90	7.70	7.40	4.70	5.00	7.40	6.60
.....	.....	.....	17.70	11.20	10.70	11.70	7.10	7.20	4.50	5.00	7.20	6.70
.....	.....	.....	16.10	10.90	10.05	11.50	7.00	7.10	4.90	5.00	7.00	6.70
.....	.....	.....	16.00	10.70	9.30	11.00	6.80	7.00	5.40	5.10	6.70	(b)
.....	.....	5.80	16.00	11.50	9.10	12.70	6.80	7.20	6.30	5.50	6.40	.....
.....	7.00	.....	16.30	12.80	9.10	12.10	6.60	7.00	7.10	5.60	6.20	.....
.....	.....	.....	16.40	13.00	8.50	11.30	6.00	8.10	7.70	5.80	6.00	.....
.....	.....	.....	16.90	13.70	8.10	10.50	5.70	10.00	7.60	5.60	6.20	6.60
.....	.....	.....	16.40	13.00	7.40	9.60	5.60	8.60	7.40	5.50	7.40	6.70
.....	.....	.....	16.10	12.80	7.70	9.40	5.40	7.20	7.00	5.40	8.40	7.10
.....	.....	.....	16.00	12.00	7.90	9.20	6.00	7.00	6.70	5.30	8.50	(b)
.....	.....	5.40	16.00	10.20	7.60	12.00	6.30	6.70	6.60	5.30	8.50	.....
.....	6.40	.....	16.10	10.40	7.30	13.90	6.30	6.20	6.50	5.20	8.00	.....
.....	.....	.....	16.00	10.70	7.00	14.30	6.40	5.60	5.20	5.20	7.70	7.10
.....	.....	.....	16.20	10.70	7.10	11.40	6.40	5.20	5.00	5.30	7.10	8.00
.....	.....	.....	16.20	10.90	7.00	9.00	6.50	4.90	6.80	5.80	7.00	7.40
.....	.....	5.10	16.30	12.15	7.20	8.80	6.90	4.80	7.60	7.90	6.80	(b)
.....	.....	.....	16.30	12.50	7.10	8.40	7.30	5.60	7.00	7.40	6.70	.....
.....	.....	.....	16.00	12.60	7.90	7.90	7.10	6.70	6.60	7.00	6.80	.....
.....	6.00	.....	15.90	12.80	8.45	7.50	7.00	7.00	5.50	6.60	6.80	7.00
.....	.....	10.40	15.10	13.40	9.90	7.30	6.80	7.90	5.60	6.00	6.60	(b)
.....	.....	8.00	14.00	14.80	12.35	9.00	6.40	7.60	5.70	5.60	6.40	.....
.....	.....	5.40	12.20	14.90	21.00	10.10	5.90	5.30	5.60	8.40	6.30	.....
.....	.....	.....	11.00	15.00	22.40	10.00	5.60	4.80	5.60	16.60	6.20	7.10
.....	.....	.....	13.80	14.90	20.00	9.50	5.30	4.70	5.50	14.00	6.00	7.60
.....	.....	.....	17.60	.....	17.00	.....	5.00	4.70	.....	12.40	.....	7.70

(a) Weekly readings January 1 to February 25 through ice.
(b) Frozen December 9 to 12, 16 to 18, 22 to 24, and 26 to 28.

Estimated monthly discharge of Connecticut River at Orford, N. H.

[Drainage area, 3,050 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	[a]6,660	[a]3,500	[a]4,637	[a]1.52	[a]1.75
February	[a]8,474	[a]2,686	[a]3,389	[a]1.11	[a]1.16
March	29,165	9,200	16,314	5.35	6.17
April	18,033	8,232	11,483	3.76	4.19
May	22,994	4,500	9,248	3.03	3.49
June	14,282	4,820	8,917	2.93	3.27
July	6,660	2,600	4,235	1.39	1.60
August	7,990	2,268	4,361	1.43	1.65
September	5,260	2,108	3,453	1.13	1.26
October	15,976	2,432	4,234	1.39	1.60
November	9,442	3,500	4,917	1.61	1.80
December	5,600	3,312	4,360	1.43	1.65
The year	29,165	2,108	6,629	2.17	29.57

[a] Weekly readings through ice from January 1 to February 25.

CONNECTICUT RIVER AT HARTFORD, CONN.

Daily readings of the height of water at Hartford have been recorded since February 8, 1896, by Edwin Dwight Graves, city engineer Connecticut River bridge and highway district, and through his courtesy have been furnished to this Bureau.

These heights are read on what is known as the "Tollhouse gage," the zero of which is set at the low-water mark of 1801.[a] The highest water ever known in the river was in May, 1854—29 feet 10 inches; the lowest, in 1858—1½ inches below zero.

This datum was used in the various surveys of the river below Hartford in 1866–67 (see previous reference); also the survey above Hartford in 1871–1878;[b] also survey of 1897.[c] It is now being used in a further survey of the river above Hartford by an engineer commission appointed by the Secretary of War to study the problem of river improvements above Hartford.

During the low-water periods the tidal wave comes up the river to Hartford. The visible effect of this wave is dependent upon the height of the water and the direction and course of the wind.

[a] See report Theodore G. Ellis, 1867, Ex. Doc. H. R. No. 153, 40th Cong., 2d sess.
[b] Engineer's Report, 1878, pp. 348–391.
[c] Engineer's Report, 1898, pp. 976–988.

From figures given in the Report of the Chief of Engineers for 1878, ges 348–391, and from other data, computations of the discharge of e Connecticut River at Hartford from 1871 to 1886, inclusive, were epared and published in Part II of the Fourteenth Annual Report the United States Geological Survey, pages 140–146.

Daily gage height, in feet, of Connecticut River at Hartford, Conn.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
.....	12.6	11.6	15.6	16.7	13.4	11.6	5.6	4.2	3.0	7.0	12.0	3.9
.....	10.3	10.7	18.9	15.0	14.5	10.3	5.4	3.9	2.4	7.0	10.2	4.0
.....	8.8	11.3	22.6	15.0	13.8	8.8	5.2	3.4	2.2	6.4	8.7	4.3
.....	7.4	10.9	25.5	13.3	12.5	7.5	4.8	3.4	3.0	5.2	7.6	4.4
.....	8.8	10.5	25.2	12.4	11.5	6.8	6.5	3.8	2.0	4.4	6.8	4.9
.....	9.6	9.5	21.7	10.8	10.6	6.5	6.5	4.7	2.0	4.7	6.2	4.4
.....	9.7	8.6	17.3	9.8	10.0	6.5	5.9	4.7	1.8	4.8	5.8	3.6
.....	9.5	7.8	13.8	9.3	9.2	6.5	5.4	4.5	2.3	4.3	5.5	3.8
.....	9.4	6.6	11.9	10.6	8.5	6.3	4.6	4.0	2.5	4.3	5.4	4.2
.....	9.0	6.4	12.3	15.7	7.8	6.0	4.2	3.5	2.9	4.1	5.2	4.8
.....	8.3	6.2	11.3	17.5	7.3	6.0	3.5	4.5	3.5	4.0	5.0	4.5
.....	7.9	5.9	10.8	17.0	6.9	6.4	3.5	7.0	3.3	4.8	5.1	4.8
.....	7.2	5.7	12.1	15.4	6.5	6.4	3.4	7.4	4.3	5.8	4.8	5.2
.....	6.5	5.5	16.7	13.6	6.0	6.0	3.4	6.9	3.4	5.8	5.0	5.2
.....	6.6	5.1	18.7	12.2	5.6	5.5	3.4	6.2	3.4	5.1	4.8	5.6
.....	6.3	4.6	17.9	11.0	5.2	5.1	3.2	5.2	4.0	4.5	4.7	6.1
.....	6.0	4.6	17.1	10.0	4.8	5.4	3.0	4.8	3.6	3.3	5.0	8.6
.....	5.8	4.4	19.4	9.3	4.6	6.1	2.8	4.0	3.4	4.0	5.2	12.6
.....	5.3	4.6	20.0	8.6	4.5	7.5	3.0	3.5	3.2	3.6	5.1	13.9
.....	5.0	4.0	18.0	8.2	4.5	7.4	3.0	3.4	3.2	3.6	5.0	13.6
.....	5.1	4.7	15.4	8.0	4.3	6.9	4.5	3.2	3.3	4.0	4.9	12.4
.....	6.3	5.0	14.0	8.0	4.2	6.0	8.0	3.0	4.4	4.1	4.7	13.2
.....	11.8	4.6	14.0	8.0	3.9	5.3	7.6	2.8	4.1	4.6	4.2	14.8
.....	13.7	4.7	15.0	8.0	3.7	5.7	7.3	2.9	3.8	4.5	4.3	14.7
.....	13.4	5.0	15.0	8.7	3.5	5.0	6.5	3.0	3.6	4.6	4.4	12.8
.....	12.0	5.1	14.0	8.4	4.0	5.0	6.5	3.4	3.7	4.3	5.4	10.9
.....	11.1	6.9	12.7	8.2	5.1	4.4	5.9	3.4	4.0	4.5	5.0	9.7
.....	10.4	9.0	11.6	9.8	6.5	4.4	5.3	3.5	4.4	6.0	4.4	8.5
.....	12.2	.....	11.4	11.0	9.9	4.5	5.0	3.5	5.3	11.0	4.0	7.5
.....	13.0	.....	13.9	10.9	12.2	5.3	4.8	3.4	6.5	14.9	3.7	7.2
.....	12.4	.....	16.2	.....	12.5	.....	4.6	3.0	.....	14.0	.....	6.8

MERRIMAC RIVER DRAINAGE BASIN.

MERRIMAC RIVER AT LAWRENCE, MASS.

Records of flow of this river at Lawrence have been kept for more han fifty years, but have never been published in full. Figures for he monthly maximum and minimum discharge from 1890 to 1897 were published in the Nineteenth Annual Report, Part IV; the daily lischarge for 1897, 1898, and 1899 in Water-Supply Paper No. 35; the laily discharge for 1900 in Water-Supply Paper No. 47. These figures are furnished by R. A. Hale, principal assistant engineer of the Essex Water Power Company.

For a portion of the year water from the Sudbury and Nashua drainage basins is wasted into the Merrimac. During the dry months a very small amount is received, therefore the drainage area is a somewhat variable quantity. The following tables give the flow of the Merrimac at Lawrence, also the quantity wasted from the Sudbury and Nashua drainage basins, which reaches the Merrimac. The latter table is based on data furnished by the Metropolitan Water and Sewerage Board of Boston. The drainage areas are as follows:

Drainage areas in Merrimac Basin.

	Square miles.
Total Merrimac River drainage basin above Lawrence	4,66
Nashua River drainage basin above gaging station	[illegible]
Sudbury drainage basin, Framingham, Dam No. 1	[illegible]
Cochituate drainage basin	[illegible]
Total Nashua, Sudbury, and Cochituate drainage basins	[illegible]
Net drainage basin of Merrimac, excluding Nashua, Sudbury, and Cochituate basins	4,45

The quantity as measured at Lawrence includes the water from Sudbury, Nashua, and Cochituate, and in getting the absolute yield of the river this should be considered in reference to the drainage areas, either by deducting it from the Merrimac flow and using the net area of the Merrimac and the net flow of the Merrimac, or by getting the total yield of both the Sudbury and Nashua with the Merrimac and using the total area.

Estimated monthly discharge of Nashua, Sudbury, and Lake Cochituate drainage basins.

Month.	Nashua River.		Sudbury River.		Lake Cochituate	
	Average yield.	Average waste.	Average yield.	Average waste.	Average yield.	Average waste.
1901.	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Second-feet.*
January	95.5	6.9	50.8	23.9	15.8	[illegible]
February	65.6	6.5	34.9	12.7	11.9	[illegible]
March	500.5	255.5	320.5	67.2	72.6	[illegible]
April	917.8	853.7	489.1	353.4	87.7	[illegible]
May	502.4	414.6	343.7	290.0	69.9	[illegible]
June	181.4	78.1	87.6	59.4	19.2	[illegible]
July	87.8	11.2	35.6	5.3	14.9	[illegible]
August	94.2	9.9	49.3	36.4	20.8	[illegible]
September	58.9	7.6	35.5	31.6	19.1	[illegible]
October	119.1	31.3	47.9	34.3	20.4	[illegible]
November	95.1	7.9	55.2	58.7	19.5	[illegible]
December	595.3	425.8	313.6	148.9	69.4	[illegible]

Estimated monthly discharge of Nashua, Sudbury, and Lake Cochituate drainage basins—Continued.

Month.	Nashua River.		Sudbury River.		Lake Cochituate.	
	Average yield.	Average waste.	Average yield.	Average waste.	Average yield.	Average waste.
1902.	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Second-feet.*	*Second-feet.*
January	317.6	136.3	205.1	203.0	39.1	19.6
February	249.5	113.5	194.8	169.2	36.5	12.5
March	739.3	691.5	488.6	342.5	113.6	90.0
April	397.1	265.7	219.3	180.2	51.7	26.1
May	200.4	58.0	86.4	57.3	18.0	11.6
June	91.5	5.8	35.3	2.5	6.0	0.0
July	60.4	5.4	7.6	2.2	7.5	0.0
August	58.0	3.9	15.7	2.2	11.4	0.0
September	48.0	4.1	20.8	2.3	13.0	0.0
October	155.8	38.0	58.8	2.3	15.4	0.0
November	124.0	9.2	51.7	20.4	13.4	0.0
December	320.8	199.7	207.0	103.9	38.7	0.0

Mean daily discharge, in second-feet, of Merrimac River at Lawrence, Mass.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1	4,628	2,888	2,360	14,080	16,296	19,479	4,048	4,869	2,010	2,929	3,150	2,435
2	4,574	2,191	1,792	12,510	15,547	16,315	2,881	4,577	2,481	2,508	2,186	4,630
3	4,284	1,630	745	12,580	15,222	15,139	2,694	3,212	4,093	2,703	2,070	3,294
4	3,850	3,919	3,189	18,100	14,601	13,616	603	2,424	3,507	3,012	4,259	3,287
5	3,343	3,007	2,851	31,650	12,554	12,666	2,633	4,404	2,926	1,635	3,168	2,882
6	2,192	2,957	2,991	34,200	11,766	11,270	2,586	3,016	2,916	1,087	3,119	2,754
7	4,462	2,526	2,906	33,950	10,749	9,972	2,403	2,951	1,831	3,626	2,931	2,065
8	3,210	2,531	2,897	61,200	9,831	9,470	3,905	4,722	1,467	2,818	3,048	1,333
9	2,872	1,916	2,116	62,511	8,815	9,653	3,260	11,252	4,086	2,682	1,936	4,103
10	3,284	640	1,851	48,756	9,053	10,520	3,083	8,627	2,879	2,686	1,460	3,628
11	3,796	3,356	4,591	38,023	10,048	9,175	3,522	6,705	2,951	2,557	3,552	4,187
12	2,595	2,726	12,620	31,463	13,099	7,948	3,913	6,982	2,355	1,731	2,878	5,111
13	2,259	2,510	14,080	26,155	15,886	7,024	2,416	5,592	2,519	607	2,618	6,865
14	4,480	2,667	11,920	22,319	14,640	6,571	2,405	4,790	1,599	3,525	2,827	6,447
15	3,402	2,516	9,600	20,832	13,081	5,519	4,315	4,358	1,749	6,149	3,697	9,440
16	3,359	1,846	7,870	19,528	11,072	4,746	3,080	3,941	3,764	13,374	2,615	34,100
17	3,626	889	5,660	17,696	9,684	5,777	2,907	2,928	3,133	11,552	2,361	41,500
18	3,757	3,312	7,690	16,317	8,362	4,808	2,832	3,965	3,182	8,474	4,972	24,200
19	2,712	2,850	6,110	15,627	9,095	4,220	2,959	4,864	1,450	6,503	3,127	15,690
20	2,348	2,785	5,980	15,010	19,104	3,916	2,292	3,619	4,232	5,038	3,138	12,580
21	4,641	2,712	5,770	13,764	28,185	4,186	2,455	3,396	2,602	5,785	3,274	10,390
22	3,408	2,803	12,390	16,027	27,308	3,286	4,055	3,078	1,790	4,575	3,478	7,100
23	3,462	1,929	15,210	21,961	21,863	3,520	3,185	3,017	4,004	4,421	2,164	7,370
24	3,388	560	13,420	26,279	18,063	4,987	2,754	1,968	2,963	3,908	1,661	6,370
25	3,363	3,272	14,110	28,294	16,986	4,382	2,802	3,185	2,615	4,239	4,785	6,750
26	2,415	2,857	13,650	31,770	17,300	4,119	2,753	5,422	2,525	2,805	3,906	9,220
27	2,265	2,476	20,800	29,915	17,588	4,238	1,779	5,132	2,641	2,659	3,893	7,760
28	4,303	2,394	26,350	23,868	18,588	4,013	629	4,721	1,759	4,527	1,461	7,722
29	3,392	.....	26,300	19,629	23,391	2,850	3,755	4,223	300	3,525	4,511	7,568
30	3,075	.....	21,600	16,732	23,766	2,239	3,193	3,659	3,367	3,200	2,705	15,858
31	3,070	.....	15,400	.....	22,417	.....	3,522	2,308	.....	3,054	.....	25,800

Mean daily discharge, in second-feet, of Merrimac River at Lawrence, Mass.—Cont'd.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	26,500	7,638	22,629	28,212	19,442	7,914	4,069	3,755	2,147	2,696	12,357	5,382
2	22,250	7,471	51,065	24,483	25,470	7,499	4,422	2,057	4,144	2,021	2,338	4,[illegible]
3	16,650	9,057	59,880	20,272	20,161	6,408	3,974	2,052	2,961	7,985	2,052	4,[illegible]
4	13,090	8,005	61,185	17,209	15,792	5,978	4,465	4,125	2,838	6,477	7,963	5,[illegible]
5	11,189	8,313	44,377	14,803	14,881	5,764	7,016	3,170	2,603	5,296	7,179	6,15[illegible]
6	9,652	7,315	28,452	12,842	14,091	5,476	6,569	2,842	1,468	6,640	6,528	4,7[illegible]
7	7,856	6,398	21,900	12,015	13,870	4,376	5,650	2,889	512	7,766	6,421	3,6[illegible]
8	8,130	5,124	19,471	11,374	12,816	3,828	4,937	2,957	2,997	8,643	5,486	3,35[illegible]
9	7,623	4,947	17,656	15,265	12,424	5,249	4,532	2,235	2,785	7,849	5,200	4,29[illegible]
10	6,985	5,981	18,624	32,204	10,881	4,697	3,841	2,226	2,780	6,242	6,443	4,42[illegible]
11	6,130	5,287	18,834	39,195	9,104	5,179	3,973	4,540	2,988	4,884	5,195	4,15[illegible]
12	5,737	5,098	18,973	35,563	9,162	4,663	2,618	5,371	4,967	4,327	5,161	4,10[illegible]
13	6,856	4,862	23,909	27,127	7,858	3,856	2,881	8,544	3,655	6,258	5,208	3,61[illegible]
14	5,387	4,635	33,547	22,988	7,690	3,732	4,508	7,500	3,280	6,370	5,295	3,52[illegible]
15	5,247	3,502	34,170	19,045	6,799	3,373	3,146	6,082	5,178	5,899	5,395	3,76[illegible]
16	5,646	3,591	28,373	16,452	6,486	5,009	3,026	4,351	4,914	5,477	5,114	4,28[illegible]
17	5,701	4,987	26,745	14,485	5,591	4,297	3,493	3,362	4,760	5,051	6,106	4,[illegible]
18	5,069	4,180	34,954	13,602	4,814	6,974	3,654	4,806	4,206	4,006	5,251	8,[illegible]
19	4,924	4,009	34,583	12,194	6,008	7,067	2,490	3,266	3,296	3,502	5,185	12,36[illegible]
20	5,821	4,194	26,041	11,090	5,260	5,850	2,595	3,123	2,624	5,263	4,976	11,6[illegible]
21	5,217	4,120	22,375	11,580	5,444	4,434	4,732	3,066	2,804	5,286	4,787	9,[illegible]
22	6,735	2,995	22,754	10,922	5,405	4,118	4,475	3,247	5,081	6,356	4,362	11,[illegible]
23	15,405	3,075	23,191	10,713	5,139	5,644	5,511	2,638	3,849	5,831	3,857	17,[illegible]
24	21,308	4,835	23,697	10,737	4,224	5,487	5,976	4,052	4,021	5,178	5,234	19,[illegible]
25	18,738	3,801	21,764	10,906	4,238	5,077	6,120	5,653	3,867	4,203	4,491	14,[illegible]
26	14,659	4,113	19,186	10,138	6,239	4,363	4,977	4,534	3,511	3,510	4,421	14,[illegible]
27	13,144	6,670	17,877	11,369	7,018	4,674	4,021	3,944	2,179	5,320	2,985	11,[illegible]
28	12,472	12,369	16,966	16,672	10,379	6,680	5,015	3,631	2,106	5,067	5,614	10,[illegible]
29	11,416	.....	15,706	15,144	13,902	5,347	3,955	2,906	4,961	15,154	4,085	9,[illegible]
30	9,689	.....	22,711	13,106	14,080	5,762	3,887	2,183	6,161	22,253	3,832	[illegible]
31	8,851	.....	31,751	.....	10,486	.....	3,627	1,551	.....	17,176	.....	9,[illegible]

SUDBURY RIVER AT FRAMINGHAM AND LAKE COCHITUATE AT COCHITUATE, MASS.

Sudbury River, a small stream of eastern Massachusetts, receives water from an area west of Framingham. It flows thence in a northerly course through meadows and swamps and joins Assabet River to form Concord River, which in turn continues northerly, entering Merrimac River immediately below the city of Lowell. Storage reservoirs have been constructed by the city of Boston, controlling the greater part of the flow from this basin.

Lake Cochituate drains into Sudbury River a short distance below Framingham. It is controlled as a storage reservoir by the Metropolitan Water Works.

Sudbury River and Lake Cochituate have been studied by the engineers of the city of Boston, the State board of health of Massachusetts, and the Metropolitan Water Board, and records of rainfall in the Sudbury Basin have been kept since 1875, and in the Cochi-

uate Basin since 1852, but the latter are considered of doubtful accuracy previous to 1872. The records of run-off from 1875 to 1898, inclusive, for Sudbury River, were published in the Twentieth Annual Report, Part IV, and those for Lake Cochituate from 1863 to 1899, inclusive, in Water-Supply and Irrigation Paper No. 35.

The following tables, furnished by Frederic P. Stearns, give the results for 1902, also the averages for twenty-eight years.
which records have been taken:

Estimated monthly discharge of Sudbury River at Framingham, Mass.

[Drainage area, 75.2 square miles.]

Month.	Run-off.		Rainfall.
	Second-feet per square mile.	Depth in inches.	
1902.			*Inches.*
January	2.728	3.145	2.52
February	2.590	2.697	6.18
March	6.497	7.491	5.84
April	2.916	3.254	4.13
May	1.149	1.325	1.86
June	.469	.523	2.89
July	.101	.117	2.94
August	.208	.240	3.40
September	.276	.308	4.54
October	.782	.902	4.44
November	.688	.767	1.45
December	2.753	3.173	6.38
The year	1.764	23.942	46.07
Average for 28 years, 1875 to 1902, inclusive.			
January	1.894	2.184	4.20
February	2.911	3.055	4.40
March	4.594	5.296	4.59
April	3.201	3.571	3.44
May	1.776	2.048	3.45
June	.732	.817	2.88
July	.292	.337	3.76
August	.456	.526	4.08
September	.366	.408	3.29
October	.801	.924	4.30
November	1.404	1.566	4.12
December	1.748	2.015	3.87
The year	1.675	22.747	46.38

Estimated monthly discharge of Lake Cochituate at Cochituate, Mass.

[Drainage area, 18.87 square miles.]

Month.	Run-off.		Rainfall
	Second-feet per square mile.	Depth in inches.	
1902.			Inches.
January	2.071	2.388	3.31
February	1.934	2.014	6.67
March	6.022	6.942	5.04
April	2.741	3.058	3.69
May	.955	1.101	1.5
June	.319	.356	2.42
July	.398	.459	3.5
August	.604	.697	4.2
September	.688	.767	4.9
October	.814	.938	4.6
November	.710	.792	1.7
December	2.052	2.366	6.2
The year	1.612	21.878	44.7
Average for 40 years, 1863–1902.			
January	1.749	2.017	3.9
February	2.510	2.636	4.0
March	3.418	3.942	4.4
April	2.627	2.932	3.7
May	1.552	1.789	3.7
June	.694	.775	2.9
July	.469	.541	4.2
August	.672	.775	4.4
September	.660	.736	3.2
October	.914	1.054	4.2
November	1.299	1.449	4.2
December	1.524	1.759	3.7
The year	1.502	20.405	47.5

SOUTH BRANCH OF NASHUA RIVER AT CLINTON, MASS.

Since July, 1896, the flow of the South Branch of Nashua River has been measured at Clinton, Mass., by the engineers of the Metropolitan Water Board. The results of these measurements have been furnished by Frederic P. Stearns, chief engineer. Beginning with 1897 the flow has been corrected for loss and gain of storage in ponds and

ıill reservoirs on the watershed, so that the results show the natural ow of the stream. The flow for 1896, however, has not been cor- ected for storage. The following tables give the results for 1902, lso the average for the years 1897–1902.

Estimated monthly discharge of South Branch of Nashua River at Clinton, Mass.

[Drainage area, 119 square miles.]

Month.	Run-off.		Rainfall.
	Second-feet per square mile.	Depth in inches.	
1902.			*Inches.*
January	2.579	2.990	2.72
February	2.168	2.258	4.91
March	6.176	7.120	5.27
April	3.341	3.728	4.36
May	1.595	1.839	2.24
June	.635	.708	2.51
July	.452	.521	3.87
August	.459	.529	3.95
September	.372	.416	4.26
October	1.471	1.696	6.36
November	.982	1.095	.93
December	2.859	3.295	7.20
The year	1.930	26.195	48.58
Average for 6 years, 1897–1902.			
January	1.919	2.212	3.68
February	2.441	2.543	4.33
March	4.913	5.666	5.05
April	4.064	4.584	4.24
May	2.207	2.544	3.90
June	1.172	1.307	3.56
July	.803	.926	4.70
August	.892	1.029	4.83
September	.514	.573	3.34
October	1.000	1.153	3.97
November	1.524	1.700	4.36
December	2.925	3.373	5.36
The year	2.030	27.560	51.32

BLACKSTONE RIVER.

The Blackstone River, rising in Massachusetts and flowing to tide water at Providence, R. I., is one of the great water-power rivers of the United States. Its flow is largely affected by the many dams built across the river for the development of water power. A station for systematically measuring the flow of the Blackstone was established in May, 1901, by John E. Hill, professor of civil engineering, Brown University, and measurements of flow have been made under his charge by four students of the university, George H. Gilbert, Henry D. Drowne, E. Vanderbilt, and R. P. Hovey. The station is located at a bridge about one-fifth of a mile west of the New York, New Haven and Hartford Railroad station at Berkeley. The drainage area at this point is 429 square miles. At this point the Blackstone River is paralleled by Blackstone canal, and measurements of the canal are usually made immediately after the measurements of the river are completed. The canal begins at the Ashton dam, three-fourths of a mile upstream, and terminates at the Lonsdale mills, 2 miles below the station. Throughout the late spring and summer the gates at Lonsdale are closed at 12.30 p. m. on Saturdays. The combined flow of the river and canal represents the total flow from the drainage area of the Blackstone above Berkeley. The gagings are made from bridges over the river and canal. The gages are vertical rods nailed to the bridges, the river gage being referred to two bench marks—the first is a large stone 20 feet south of road, 90 feet east of bridge, and 12 feet southwest of old oak tree, the elevation being [illegible] feet; the second is the west end of stone doorsill to office of Berkeley Mills; elevation, 18 feet. There are two benches for the canal gage, the first being the top of the same stone as used for the river gage, the elevation being 2.10 feet below the zero of the gage rod, while the stone sill just described has an elevation of 7.03 feet. The banks of both the river and canal are high, the river having a straight course above the station, though slightly curved below. The gages were read twice a day, 7.30 a. m. and 4.30 p. m., by Joseph A. Ray, master mechanic in the Berkeley Mills, from May 17 to August 17, and since September 22 by A. E. Glover, station agent, New York, New Haven and Hartford Railroad.

The following tables of discharges and gage heights give the data which was collected to that date.

February 27: Gage height, 4.27 feet; discharge in river, 2,118 second-feet.
March 4: Gage height, 5.10 feet; discharge in river, 3,791 second-feet.
February 27: Gage height, 3 feet; discharge in canal, 74 second-feet.

Daily gage height, in feet, of Blackstone River at Berkeley, R. I.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.											
1	.....	4.50	8.35	4.25	4.45	4.10	3.90	3.90	4.10	4.20	4.00
2	.....	4.50	7.75	4.35	4.45	4.20	4.00	3.90	4.05	4.20	4.00
3	.....	3.85	6.75	4.30	4.15	4.20	3.90	3.90	4.00	4.30	3.90
4	.....	4.50	5.10	4.30	3.85	4.10	3.90	3.80	3.90	4.30	3.90
5	5.15	4.40	4.85	4.35	4.35	4.10	4.00	3.95	4.00	4.40	4.05
6	5.05	4.30	4.70	3.90	4.30	4.10	4.00	3.85	4.00	4.40	4.00
7	4.50	4.30	4.90	4.30	4.30	4.10	4.15	3.95	4.00	4.45	3.90
8	4.45	4.30	5.05	4.40	4.15	4.00	4.20	4.00	4.00	4.30	3.85
9	4.80	3.30	5.25	4.65	4.15	4.00	4.20	3.90	4.20	4.35	4.10
10	4.20	4.35	5.35	5.25	4.15	4.10	4.10	3.80	4.20	4.40	3.95
11	4.40	4.30	5.50	4.80	4.00	4.10	3.90	3.80	4.10	4.40	3.90
12	4.00	4.80	5.45	4.50	4.20	4.10	3.90	3.90	4.20	4.25	4.10
13	4.15	4.15	5.50	3.90	4.80	4.25	3.80	4.10	4.00	4.30	3.95
14	4.05	4.10	5.30	4.60	4.20	4.20	4.05	4.10	4.00	4.50	3.90
15	4.20	4.25	4.70	4.50	4.25	4.00	4.15	3.95	4.20	4.50	4.00
16	4.15	4.00	4.00	4.60	4.15	4.10	4.20	3.90	4.20	4.40	.....
17	4.05	4.20	5.15	4.40	4.05	4.00	4.30	3.80	4.10	4.30	.....
18	4.00	4.20	6.00	4.25	4.10	4.00	4.25	3.95	4.20	4.30	.....
19	3.95	4.30	5.55	3.95	4.20	4.05	4.20	4.10	4.20	4.30	.....
20	4.05	4.30	4.75	3.80	4.20	4.10	4.00	4.10	4.20	4.20	.....
21	4.25	4.25	4.55	4.40	4.05	3.90	4.00	4.00	4.05	4.10	.....
22	5.05	4.25	4.25	4.30	4.00	3.80	3.90	4.00	4.00	4.10	.....
23	5.60	4.80	4.00	4.20	4.00	4.00	3.90	3.90	3.90	4.20	.....
24	4.60	4.25	4.40	4.05	4.05	4.00	4.00	3.95	3.90	4.00	.....
25	4.50	4.35	4.40	4.20	4.00	4.10	4.00	4.00	4.05	4.00	.....
26	4.25	4.40	4.45	3.90	4.05	4.20	4.10	4.10	4.15	4.30	.....
27	4.40	4.45	4.30	3.90	4.10	4.10	4.00	4.10	4.20	4.25	.....
28	4.50	5.15	4.10	4.30	4.20	4.10	3.90	4.00	4.10	4.20	.....
29	4.65	.....	4.20	4.25	4.20	3.90	3.90	4.00	4.05	4.20	.....
30	4.60	.....	4.20	4.25	4.25	4.10	4.00	3.95	4.15	4.20	.....
31	4.60	.....	4.65	.....	4.20	.....	4.05	4.10	.....	4.10	.....

Daily gage height, in feet, of Blackstone canal at Berkeley, R. I.

Day.	Jan.	Feb.	Mar.[a]	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1902.											
1		2.90		3.25	3.25	2.90	3.10	2.80	2.30	2.30	
2		3.00		3.20	3.30	2.90	2.90	2.60	2.40	2.35	
3		3.00		3.15	3.25	2.85	2.90	2.60	2.35	2.30	
4		2.90		3.05	3.05	2.80	3.00	2.60	2.30	2.30	
5	3.40	2.90		3.05	3.10	2.70	2.95	2.60	2.25	2.30	
6	3.05	2.90		3.00	3.00	2.90	3.00	2.65	2.40	2.30	
7	2.90	2.90		3.15	3.10	2.80	2.85	2.60	2.30	2.35	
8	2.90	2.90		3.15	3.10	2.95	2.90	2.60	2.30	2.40	
9	2.90	3.20		3.30	3.15	2.90	2.90	2.50	2.30	2.30	
10	2.90	3.00		3.25	3.20	(b)	2.85	2.60	2.30	2.10	
11	3.00	2.95		3.20	3.30	(b)	2.85	2.60	2.40	2.15	
12	3.10	2.90		3.00	3.05	(b)	2.95	2.65	2.30		
13	3.00	3.00		2.90	3.05	(b)	(b)	2.70	2.30		
14	2.95	3.00		3.10	2.90	(b)	2.80	2.65	2.30		
15	2.90	3.10		3.10	3.00	3.00	2.80	2.60	2.30		
16	2.90	3.20		3.05	2.80	2.90	2.80	2.70	2.30		
17	2.90	3.00		3.05	1.80	2.80	2.90	2.80	2.30		
18	2.90	2.90		2.90	2.90	2.80	2.80	2.60	2.40		
19	3.00	2.90		3.00	2.95	2.90	2.80	2.30	2.30	2.10	
20	2.90	3.05		3.30	3.00	2.85	(b)	2.30	2.25	2.45	
21	2.90	3.00		3.20	3.05	2.95	(b)	2.30	2.30	2.80	
22	3.20	3.10		3.10	3.00	3.05	(b)	2.30	2.10	2.50	
23	3.30	3.20		3.10	2.95	2.90	2.80	2.50	2.25	2.30	
24	3.20	2.95		3.10	(b)	2.95	2.70	2.50	2.30	2.45	
25	3.10	3.00		3.10	(b)	3.00	2.70	2.30	2.45	2.30	
26	3.00	3.10		3.15	(b)	2.90	2.80	2.30	2.35	2.70	
27	3.00	3.15	3.20	3.20	2.85	2.90	2.70	2.35	2.25	2.70	
28	2.90	3.35	3.10	3.10	2.90	2.95	2.75	2.40	2.25	2.80	
29	2.95		3.10	3.10		2.90	2.75	2.40	2.10	2.00	
30	2.90		3.60	3.10		2.90	2.70	2.30	2.20	2.00	
31	2.90		3.45				2.70	2.30		2.00	

[a] No records on account of canal bank having washed out. [b] Repairing canal.

WATER POWERS OF NEW YORK.

The following pages contain the results of gagings of streams in State of New York, made by the Division of Hydrography of t United States Geological Survey in cooperation with the Sta engineer of New York. The work has been under the immedi supervision of Mr. Robert E. Horton. Acknowledgment is mad the hearty cooperation and assistance afforded by Edward A. Bu State engineer and surveyor, and William Pierson Judson, dep State engineer, as well as by many civil engineers, water-power us and other individuals.

The methods of stream gagings utilized in New York State ha been fully described in Water-Supply Paper No. 65, pages 91 to The methods there described have been continued during the ye 1902, and, in addition, particular attention has been devoted to se ing reliable data relative to the yield of streams during the win months and to the experimental determination of the best method

urrent-meter use on each of the streams. In addition, some attention has been devoted to the gagings of some very small watersheds ot subject to any storage or artificial control.

Information concerning the yield of streams during the winter onths is of great value wherever water power is used for electric-ghting purposes, as the heaviest load and hardest service usually ecur in the winter. It is, however, a somewhat more difficult matter o secure reliable records of stream flow when the rivers are frozen ver than during the open season. Where gaging stations are located t dams ice is likely to accumulate on the crest of the overflows, iminishing their effective capacity. At current-meter gaging stations the rating curves applicable during summer months may be napplicable when the stream is frozen over, owing to the increase in he wetted perimeter.

Measurements of the run-off from small, uncontrolled watersheds f the Appalachian region are a matter of growing interest, inasmuch s the public water supplies of very many of the cities and towns of he region are drawn from such sources in preference to taking supplies from larger rivers and streams which contain greater pollution rom sewage and manufacturing waste. The extent to which such agings of small watersheds can be carried on is limited, owing to the act that to obtain a given per cent of precision equal if not greater are is required in gaging a small stream than in gaging a large one. The number of such streams is, moreover, very great, and the number of persons likely to be interested and directly benefited by the measurement of any single stream is relatively small. Especial thanks are rendered to William S. Bacot, consulting engineer, Utica, N. Y.; also to the Consolidated Water Company, of Utica, N. Y., and the Greenwich Water Company, of Greenwich, Conn., for affording facilities for obtaining gaging records on a number of small natural watersheds in New York State.

The appropriating clause in chapter 594 of the New York State Laws of 1902 requires that the State shall cooperate with the United States Geological Survey in "determining the water supply available for canals and for potable and domestic uses and for the development of water power."

As illustrating the value of water resources of New York to the State, the following statistics from the Twelfth United States Census are given. They show an aggregate power of installed water wheels of 330,543 horsepower in 1900. In 1880 the water power in use in the State was determined by the census officials to be 219,348 horsepower. Since the census of 1900 was taken water-power development costing many millions of dollars has been completed. A large part of the power thus rendered available is utilized for electric lighting of municipalities and for electric traction purposes, two classes of power users which are not represented in the census returns.

The following table is a list of the various industries in New York which depend upon water power:

Industries in New York State dependent on water power.

Industry.	Number of establishments.	Horse power	Industry.	Number of establishments	Horse power
Agricultural implements	19	1,101	Linen goods	1	[illegible]
Boots and shoes	7	590	Lumber	278	[illegible]
Brick and tile	1	50	Lumber and timber products	450	[illegible]
Carpets and rugs	5	1,660	Paper	175	[illegible]
Carriages and wagons	25	1,006	Printing and publishing	56	[illegible]
Chemicals	14	514	Ship building	4	[illegible]
Cordage and twine	3	800	Shoddy	5	[illegible]
Cotton goods	16	8,494	Silk manufacturing	7	[illegible]
Cotton small wares	1	36	Wool hats	2	[illegible]
Dyeing and finishing	5	560	Woolen goods	46	[illegible]
Felt goods	4	862	Worsted goods	3	[illegible]
Flour and grist mills	1,053	58,775	Total	[illegible]	[illegible]
Hosiery and knit goods	71	7,164			
Iron and steel	3	1,300			
Leather, tanned and curried	34	1,419			

LAKE ONTARIO DRAINAGE BASIN.

MOOSE RIVER AT MOOSE RIVER, N. Y.

The gaging station on this stream is situated at the village of Moose River, 4 miles below McKeever railroad station. It was established June 5, 1900. The watershed is described in Water-Supply Paper No. 65, pages 98 to 100, and the mean of the two gage readings which are taken each day, is tabulated for 1900 in Water-Supply Paper No. 49, page 235, and for 1901 in Water-Supply Paper No. 65, page 99. The average daily gage heights for 1902 deduced from the observations by Christopher Hannan, the gage reader, are given in the accompanying table.

Mean daily gage height, in feet, of Moose River at Moose River, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	1.75	1.15	2.85	4.60	4.90	2.80	1.85	1.05	0.60	1.05	2.55	1.85
	2.15	1.10	3.85	4.20	3.65	2.65	2.05	1.35	.90	.85	2.35	1.75
	2.20	1.20	5.05	3.95	3.60	2.40	2.75	1.60	.65	.95	2.15	1.65
	2.10	1.30	5.25	3.65	3.65	2.70	4.50	1.55	.70	1.05	1.95	2.30
	2.25	1.40	4.80	3.45	3.55	2.90	3.55	1.40	.85	1.20	1.75	2.30
	2.45	1.40	4.20	3.30	3.05	2.45	2.90	1.75	.80	1.30	1.75	1.90
	2.25	1.50	3.75	3.25	2.80	2.25	2.50	3.10	.80	1.45	1.75	1.50
	2.15	1.40	3.55	3.20	2.45	2.15	2.25	2.85	.55	1.55	1.55	1.20
	2.15	1.40	3.15	3.10	2.20	2.70	2.05	3.50	.65	1.45	1.55	1.75
	1.95	1.40	2.85	4.60	2.05	2.55	1.85	2.70	.80	1.30	1.45	1.65
	1.60	1.40	2.65	4.45	1.95	2.45	1.65	2.25	.85	1.25	1.25	1.75
	1.25	1.30	2.65	4.20	1.70	2.25	1.55	2.70	1.10	1.20	1.60	1.85
	2.25	1.35	3.40	3.60	1.55	2.10	1.45	2.10	1.40	1.10	2.25	1.75
	2.45	1.45	4.65	3.85	1.65	2.05	1.55	1.80	1.30	1.45	2.90	1.75
	2.40	1.45	3.45	3.25	1.45	2.25	1.80	1.45	1.35	1.55	2.70	1.85
	2.25	1.45	4.50	4.00	1.25	2.45	1.75	1.25	1.25	1.35	2.35	1.70
	2.05	1.45	6.00	4.40	1.20	2.25	1.45	1.15	1.15	1.15	1.95	2.00
	2.25	1.45	(a)	3.40	1.10	2.05	1.35	1.05	1.25	1.15	1.55	2.30
	2.05	1.60	(a)	2.85	1.05	1.85	1.65	1.05	1.25	1.25	1.75	2.25
	1.85	1.75	(a)	2.50	1.10	2.15	2.95	1.00	1.10	1.25	1.75	2.05
	1.75	1.90	4.50	2.85	1.00	2.25	2.25	1.05	1.15	1.45	1.65	1.90
	1.70	1.90	4.15	2.50	.85	2.85	2.05	1.10	1.20	1.55	1.65	2.90
	1.70	2.00	3.80	3.05	1.10	2.40	1.85	1.15	1.10	1.35	1.85	3.65
	1.80	2.10	3.75	2.75	1.80	1.95	1.55	1.10	1.05	1.25	1.95	3.35
	1.65	2.10	3.60	2.50	2.65	1.85	1.45	1.95	1.20	1.45	1.75	3.05
	1.55	2.05	3.40	3.10	3.30	1.95	1.80	.85	1.25	1.65	1.75	2.85
	1.35	2.05	3.15	4.80	3.90	2.40	1.40	.80	1.20	1.75	1.75	2.65
	1.40	2.25	3.10	4.25	3.45	2.10	1.05	.75	1.30	1.95	1.95	2.45
	1.30	.....	4.05	3.75	3.25	1.85	.95	.65	1.20	3.35	1.80	2.25
	1.30	.....	6.40	4.75	3.35	1.55	1.00	.65	1.25	3.25	1.75	2.05
	1.20	.....	5.20	.....	3.50	.....	1.10	.65	.....	3.20	.....	1.95

(a) Ice breaking up; water above top of gage.

BEAVER RIVER NEAR CROGHAN, N. Y.

Beaver River, like Moose River, is a stream draining a portion of ıe western Adirondack slope of New York. The watershed is escribed in Water-Supply Paper No. 65, pages 100 to 102. The aging station was established at Tisses Bridge, situated between the illages of Croghan and Belfort, May 17, 1901. Daily gage heights om the readings taken once each day by Nicholas Tisse are given or 1901 in the Water-Supply Paper above cited. The observations or 1902 are contained in the following table.

August 6, 1902, a current-meter discharge measurement was made y C. C. Covert. Gage height, 2.32; discharge, 554 second-feet.

Daily gage height, in feet, of Beaver River at Tisses Bridge, near Croghan, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.0	2.5	3.4	4.5	4.5	3.4	3.0	2.5	2.2	2.0	2.7	2.6
2	2.9	2.4	4.5	4.4	2.0	3.2	2.7	2.5	2.0	2.1	2.5	2.6
3	2.8	2.4	4.4	3.7	4.0	3.0	2.4	3.4	2.6	2.2	2.2	2.6
4	2.8	2.4	3.9	3.5	4.0	3.2	2.4	3.0	2.4	2.2	2.7	2.7
5	2.9	2.4	3.7	3.4	4.5	3.0	2.5	2.4	2.0	2.0	2.6	2.7
6	2.7	2.4	3.5	2.0	4.2	3.4	2.5	2.4	2.0	2.2	1.9	2.7
7	2.7	2.4	3.4	1.4	4.4	3.6	2.4	2.2	2.0	2.1	1.9	2.6
8	2.7	2.4	2.4	3.5	5.0	3.6	2.5	2.3	2.0	2.2	2.0	2.6
9	2.6	2.3	3.5	4.2	4.4	3.2	2.4	2.4	2.1	2.2	2.2	2.6
10	2.6	2.4	2.5	4.1	4.0	3.9	2.5	3.0	2.0	2.1	2.4	2.6
11	2.5	2.3	2.7	4.2	3.6	3.6	2.5	2.7	2.2	2.1	3.0	2.6
12	2.5	2.3	3.3	4.4	2.9	3.2	2.5	2.4	2.3	2.2	3.2	2.6
13	2.5	2.3	4.4	4.3	4.2	2.5	2.4	2.0	2.2	2.0	3.2	2.6
14	2.5	2.2	4.9	3.4	2.4	2.2	2.5	2.0	2.2	2.0	2.9	2.6
15	2.5	2.4	4.8	3.0	2.2	2.4	2.6	2.0	2.0	1.9	2.7	2.6
16	2.5	2.4	4.9	3.0	4.4	3.2	3.0	2.1	1.8	1.9	2.7	2.6
17	2.5	2.4	5.0	3.2	5.0	3.7	3.2	3.2	1.8	2.2	2.4	2.6
18	2.5	2.6	5.4	2.9	4.6	2.8	3.2	3.4	2.0	2.2	2.4	2.6
19	3.2	2.7	5.2	4.2	4.2	3.3	3.0	3.1	1.9	2.3	2.7	2.6
20	3.1	2.8	4.8	4.3	2.6	3.8	3.0	2.7	1.9	2.2	2.7	2.6
21	3.1	2.8	4.4	2.3	4.2	3.8	3.0	2.4	1.8	2.3	2.7	2.6
22	2.9	2.9	4.0	2.6	4.4	3.5	2.9	3.3	1.8	2.4	2.2	2.6
23	2.7	2.9	4.4	3.4	4.2	3.8	2.8	3.2	1.9	2.4	2.4	2.6
24	2.6	2.9	4.4	4.2	4.2	2.6	2.8	3.0	1.8	2.2	2.4	2.6
25	2.5	2.7	4.0	3.5	5.2	2.8	2.9	3.0	2.0	2.3	2.4	2.6
26	2.5	2.8	3.9	3.2	5.4	2.4	2.8	2.5	1.8	3.2	2.4	2.6
27	2.5	2.9	4.0	4.8	5.6	2.2	2.5	2.2	1.8	3.0	2.5	2.6
28	3.3	3.7	3.7	3.0	4.2	2.4	2.5	2.2	2.0	3.0	2.5	2.6
29	3.1	.....	4.0	4.6	3.4	2.4	2.4	2.2	2.0	2.9	2.5	2.6
30	2.7	.....	4.5	3.7	3.5	2.3	2.6	2.2	2.1	2.8	2.4	2.6
31	2.2	.....	4.4	.....	3.4	.....	2.4	2.1	.....	2.7	.....	2.6

BLACK RIVER NEAR FELTS MILLS, N. Y.

A gaging station maintained on Black River at Huntington's dam, near Watertown, from February 22, 1897, to December 13, is described in Water-Supply Paper No. 49, pages 236 to 239, and Water-Supply Paper No. 65, pages 102 to 105. Owing to the washout of a portion of the right wing of the Huntingtonville dam in freshet, the record for Black River was transferred during 1902 to the dam of the Black River Traction Company, 2 miles above Felts Mills.

This dam is situated 9 miles above Watertown and 7 miles above the Huntingtonville gaging station, on the same stream. The drainage area is estimated at 1,851 square miles, or 37.5 square miles more than that at Huntingtonville. The intervening area is mainly drained by two small streams—Townsend Creek and Rutland Hollow Creek.

The dam is of squared timber and has a slope on the upstream face 2.86 horizontal to 1 vertical. The crest is protected by boiler plate, d the downstream face is vertical, giving a free overfall. The ain crest is 380.6 feet in length, is level, and at an elevation of 7.96 feet above tide. There are two additional sections on the right le; one, at an elevation of 590.96 feet, is 14.1 feet long, and the her, at an elevation of 593.46 feet, is 17.9 feet in length.

A similarly constructed dam 117 feet long at the left bank serves as auxiliary spillway and as a headrace wall. It has an average crest evation of 591 feet.

The gage is attached vertically to a crib at the juncture of the main id auxiliary spillways, 8 feet upstream from the crest, and a correc- on is made to the gage readings for velocity of approach during gh water. The discharge over the spillways has been calculated means of the weir formula, using coefficients derived from Cornell periment No. 5 for a dam of similar cross section. The dam was nstructed in 1900, rests on limestone foundation, and is very nearly ater-tight. The headrace is closed by a bulkhead, no water wheels aving been installed.

The gage readings are taken twice daily, at 7 a. m. and again at 6 m., by A. H. Tucker. A record of high water was kept at this im May and June, 1901. The results are not available for publica- on at present.

ean daily flow, in second-feet, of Black River at Black River Traction Company's dam, near Felts Mills, N. Y., for 1902.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
.....	.....	3,460	4,220	7,180	5,560	18.....	.....	3,805	4,360	5,880	5,250
.....	.....	3,590	4,140	6,200	5,100	19.....	.....	3,720	4,060	5,780	6,550
.....	.....	3,940	4,280	5,880	4,940	20.....	.....	3,400	4,565	5,880	6,300
.....	.....	3,860	3,800	5,100	8,740	21.....	.....	3,000	4,800	5,245	6,830
.....	.....	3,665	3,180	4,500	7,920	22.....	.....	3,720	5,100	5,245	7,610
.....	.....	3,460	4,000	4,420	5,880	23.....	.....	3,540	4,500	4,500	9,960
.....	.....	2,860	4,800	4,420	6,040	24.....	.....	3,130	4,940	5,780	10,830
.....	.....	4,080	4,800	4,500	5,660	25.....	.....	3,265	4,360	5,160	9,720
.....	.....	4,140	5,000	4,420	5,400	26.....	.....	3,540	4,420	4,720	9,070
.....	.....	4,140	4,650	4,280	5,190	27.....	.....	3,180	4,800	5,720	7,700
.....	.....	5,245	4,650	4,220	4,660	28.....	.....	3,940	5,245	6,200	6,800
.....	.....	4,800	3,940	4,280	4,020	29.....	3,590	4,280	7,285	6,200	6,300
.....	.....	4,280	4,140	8,370	4,010	30.....	3,590	3,540	8,370	5,190	6,020
.....	.....	3,665	4,940	8,840	4,170	31.....	3,400	.....	8,465	.....	5,800
.....	.....	4,080	5,310	9,080	3,940	Average..	3,527	3,771	4,857	5,655	6,265
.....	.....	3,940	4,940	7,285	4,310						
.....	.....	3,860	4,420	6,200	3,960						

Estimated monthly discharge of Black River at Black River Traction Company's dam, near Felts Mills, N. Y.

[Drainage area, 1,851 square miles.]

Month.	Discharge in second-feet.			Run-off	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
August 29–31			3,527	1.90	[illegible]
September	5,245	3,000	3,771	2.04	[illegible]
October	8,465	3,180	4,857	2.62	[illegible]
November	9,080	4,220	5,655	3.05	[illegible]
December	10,830	3,940	6,265	3.38	[illegible]

SALMON RIVER NEAR PULASKI, N. Y.

The gaging station on this stream is located at Fox Bridge, 2 miles above Pulaski village. The station was established September 3, 1900, and is described in Water-Supply Paper No. 49, page 234, and in No. 65, pages 105 to 107, where gage heights and estimated daily discharge are given.

Owing to obstruction of the stream by ice, and injury to the gage, the Salmon River record was interrupted during the winter of 1901–2.

A new gage was erected July 23, 1902, and the record resumed. The datum of the weight gage is at an elevation of 87.21, or 1.2 feet below that of the original gage. All gage readings and discharge measurements have been reduced to the original or board gage datum. Gage readings are taken twice daily by S. J. Fox. The gage is of the weight and wire variety, with a 15-foot decimal scale, near the center of the right bridge span. The following current-meter discharge measurements have been made during 1902:

Current-meter discharge measurements of Salmon River near Pulaski, N. Y.

Date.	Hydrographer.	Gage height.	Discharge.
		Feet.[a]	Second-feet.
October 17	R. E. Horton	2.85	[illegible]
July 23	H. R. Beebe	3.29	[illegible]
July 2	Horton and Beebe	3.74	[illegible]
July 5	H. R. Beebe	4.73	[illegible]
July 6	do	4.83	[illegible]
Do	do	4.86	[illegible]

[a] Referred to old or original gage datum.

Salmon River, in common with other streams tributary to eastern Lake Ontario, is subject to great obstruction by anchor ice. Owing

this, separate discharge measurements are required for the winter ason before the gage readings for the ice period can be reduced to uantities of discharge. Arrangements have been made for the tak- g of such measurements during the coming winter.

Mean daily flow, in second-feet, of Salmon River near Pulaski, N. Y., for 1902.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
.....	.....	394	294	378	692	708	18	.....	442	246	506	692	1,301
.....	.....	1,640	330	330	618	618	19	.....	756	220	650	820	1,110
.....	.....	884	378	378	570	674	20	.....	692	246	735	905	990
.....	.....	650	330	330	554	2,135	21	.....	554	234	618	756	862
.....	.....	490	474	282	258	1,244	22	.....	554	246	522	692	1,015
.....	.....	535	282	570	522	692	23	862	671	234	570	1,215	883
.....	.....	554	294	246	650	586	24	714	586	234	634	1,010	1,098
.....	.....	820	378	258	586	538	25	714	474	234	798	820	1,131
.....	.....	820	362	777	388	442	26	607	410	246	671	735	1,011
.....	.....	692	1,470	586	474	554	27	538	394	294	708	862	905
.....	.....	820	799	506	474	708	28	671	362	294	947	1,157	777
.....	.....	1,325	586	426	474	798	29	535	306	306	1,301	798	884
.....	.....	798	474	394	1,914	841	30	346	294	378	976	862	905
.....	.....	1,442	394	618	1,552	1,011	31	362	282	.....	777	.....	841
.....	.....	490	362	884	1,131	1,032	Average	594	611	375	615	796	984
.....	.....	410	346	692	976	1,340							
.....	.....	394	282	998	735	1,340							

Estimated monthly discharge of Salmon River near Pulaski, N. Y.

[Drainage area, 264 square miles.]

Month.	Mean discharge in second-feet.	Run-off.	
		Second-feet per square mile.	Depth in inches.
1902.			
July	594	2.25	2.59
August	611	2.32	2.67
September	375	1.42	1.58
October	615	2.33	2.69
November	796	3.02	3.37
December	934	3.54	4.08

CHITTENANGO CREEK AT CHITTENANGO, N. Y.

This gaging station, which was established May 22, 1901, is described in Water-Supply Paper No. 65, pages 114 to 116, where daily gage heights and discharge measurements for 1901 may be found. The greatest known freshet on this stream occurred December 15, 1901. The water rose to elevation 7 on the gage board. This freshet went over the tops of the abutments and the adjacent highway. It also caused scour underneath the bridge, so that the discharge measure-

ments of 1902 are not strictly comparable with those of 1901 for similar stages of the stream. The following current-meter measurements have been made during 1902:

Current-meter discharge measurements of Chittenango Creek at Chittenango, N. Y.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
December 13	C. C. Covert	1.70	6[illegible]
August 23	do	1.77	[illegible]
April 2	E. C. Murphy	2.33	3[illegible]
Do	do	2.33	[illegible]
July 2	R. E. Horton	2.34	[illegible]
Do	do	2.36	216
July 7	H. R. Beebe	2.50	280
Do	do	2.49	280

[a] At Polytechnia street bridge.

Mean daily gage height, in feet, of Chittenango Creek at Chittenango, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	2.00	1.80	4.95	2.30	1.70	1.85	2.25	2.35	1.45	1.90	1.90	[illegible]
2	2.00	1.80	4.52	2.30	1.70	1.80	2.00	2.45	1.65	2.15	1.90	[illegible]
3	2.00	4.05	4.10	2.20	1.70	2.00	2.50	2.20	1.60	1.90	1.90	[illegible]
4	2.00	2.80	3.50	2.30	1.70	3.65	2.30	2.10	1.60	1.90	2.00	[illegible]
5	2.00	2.90	3.00	2.30	1.70	2.70	2.40	2.00	1.60	1.90	2.90	[illegible]
6	1.95	2.60	2.30	2.80	1.70	2.40	2.73	3.00	1.60	2.10	2.50	[illegible]
7	1.85	2.60	2.45	2.30	1.70	2.20	2.80	2.40	1.55	2.20	2.20	[illegible]
8	1.80	2.30	2.60	2.20	1.70	2.50	2.50	2.45	1.50	2.25	2.15	[illegible]
9	1.70	2.00	2.60	2.90	1.70	2.50	2.30	2.25	1.65	2.20	2.10	[illegible]
10	1.70	1.85	2.60	3.05	1.70	2.60	2.68	2.20	2.05	2.10	1.95	[illegible]
11	1.70	1.70	2.77	2.60	1.65	2.75	2.35	2.20	1.70	2.10	1.85	[illegible]
12	1.70	1.70	4.05	2.60	1.60	2.90	2.10	2.10	1.60	2.05	1.95	[illegible]
13	1.70	1.70	4.30	2.60	1.60	2.50	2.00	2.00	1.50	1.95	1.90	[illegible]
14	1.70	1.70	3.30	2.50	1.60	2.35	2.20	1.95	1.50	1.85	1.90	[illegible]
15	1.70	1.70	3.10	2.50	1.60	2.65	2.25	1.90	1.70	1.80	2.05	[illegible]
16	1.70	1.70	3.10	2.38	1.60	2.75	2.20	1.85	1.70	1.85	2.00	[illegible]
17	1.70	1.70	4.30	2.20	1.60	2.45	2.05	1.90	1.70	2.00	1.95	[illegible]
18	1.70	1.70	3.30	2.20	1.60	2.20	2.00	1.90	1.70	2.10	1.90	[illegible]
19	1.70	1.70	2.80	2.20	1.70	2.13	2.00	1.90	1.70	2.33	1.90	[illegible]
20	1.70	1.70	2.60	2.20	1.80	2.10	2.65	1.85	1.70	1.95	1.80	[illegible]
21	1.70	1.70	2.60	2.10	1.75	2.20	2.65	1.80	1.70	1.75	1.80	[illegible]
22	1.85	1.80	2.80	2.00	1.70	2.10	3.25	1.80	1.70	1.75	1.80	
23	1.80	1.70	2.80	1.9	1.70	2.00	2.50	1.75	1.65	1.85	1.80	[illegible]
24	1.70	1.70	2.50	1.9	1.70	1.90	2.35	1.70	1.60	1.90	1.80	[illegible]
25	1.70	1.70	2.50	1.9	1.80	1.90	2.15	1.70	1.60	1.90	1.65	[illegible]
26	1.70	1.70	2.50	1.9	2.15	2.20	2.10	1.70	1.90	1.90	1.65	[illegible]
27	2.00	1.70	2.40	1.8	1.80	2.05	3.25	1.60	1.90	1.90	1.70	[illegible]
28	1.90	3.50	2.40	1.8	1.85	1.90	2.80	1.60	1.90	3.10	1.75	[illegible]
29	1.80	.....	2.40	1.7	2.10	1.95	2.45	1.50	1.85	2.45	1.75	[illegible]
30	1.80	.....	2.40	1.7	2.10	2.10	2.20	1.50	1.80	2.10	1.75	[illegible]
31	1.80	.....	2.40	.....	2.00	.....	2.30	1.50	.....	1.95	.....	[illegible]

SKANEATELES OUTLET AT WILLOW GLEN, N. Y.

A description of the watershed of Skaneateles Lake, including gagings at various points from 1890 to the end of 1901, is given in Water-upply Paper No. 65, pages 116 to 128. The following table gives the ctual flow in the outlet for each day during 1902, as calculated by he Francis formula from readings taken daily at the Willow Glen 'eir. A table is also given showing the corresponding run-off from he watershed. The amount of diversion for the water supply of Syracuse from July, 1901, to September, 1902, has been furnished by the 'ater department of Syracuse. The diversion added to the actual ow in the outlet comprises the total run-off of the watershed. A able showing these quantities is also given.

Mean daily flow, in second-feet, of Skaneateles outlet at Willow Glen weir, New York.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	72.2	69.6	91.2	74.7	74.7	74.7	80.0	132.5	156.6	129.2	116.2	91.2
2	72.2	69.6	91.2	74.7	74.7	74.7	77.3	135.8	116.2	129.2	116.2	91.2
3	72.2	69.6	91.2	74.7	74.7	77.3	85.5	135.8	116.2	116.2	116.2	91.2
4	72.2	69.6	80.0	74.7	74.7	80.0	80.0	135.8	116.2	116.2	116.2	91.2
5	72.2	69.6	80.0	74.7	74.7	77.3	85.5	135.8	116.2	116.2	116.2	91.2
6	72.2	69.6	80.0	74.7	74.7	74.7	85.5	135.8	116.2	116.2	116.2	91.2
7	72.2	69.6	74.7	74.7	74.7	77.3	80.0	135.8	116.2	116.2	116.2	91.2
8	72.2	69.6	74.7	77.3	74.7	80.0	85.5	135.8	116.2	116.2	116.2	91.2
9	72.2	69.6	80.0	77.3	74.7	77.3	85.5	139.1	116.2	116.2	116.2	91.2
10	72.2	69.6	74.7	80.0	74.7	74.7	91.2	135.8	116.2	116.2	116.2	91.2
11	72.2	69.6	74.7	74.7	74.7	77.3	91.2	135.8	116.2	116.2	116.2	91.2
12	72.2	69.6	77.3	74.7	74.7	74.7	91.2	156.6	116.2	116.2	116.2	91.2
13	72.2	69.6	77.3	74.7	74.7	77.3	94.2	155.6	116.2	116.2	116.2	91.2
14	72.2	69.6	74.7	74.7	74.7	91.2	94.2	156.6	116.2	116.2	116.2	91.2
15	72.2	69.6	74.7	74.7	74.7	80.0	94.2	156.6	116.2	116.2	116.2	80.0
16	72.2	69.6	74.7	74.7	74.7	80.0	94.2	156.6	135.8	116.2	116.2	80.0
17	72.2	69.6	74.7	74.7	74.7	74.7	94.2	156.6	135.8	116.2	116.2	80.0
18	72.2	69.6	74.7	74.7	74.7	74.7	94.2	156.6	160.2	116.2	116.2	80.0
19	72.2	69.6	74.7	74.7	74.7	74.7	97.2	156.6	160.2	116.2	116.2	80.0
20	69.6	69.6	74.7	74.7	74.7	74.7	97.2	156.6	160.2	116.2	116.2	80.0
21	69.6	69.6	74.7	74.7	74.7	74.7	116.2	156.6	129.2	116.2	116.2	80.0
22	69.9	69.6	74.7	74.7	74.7	77.3	116.2	156.6	129.2	116.2	116.2	80.0
23	69.6	69.6	74.7	74.7	74.7	77.3	116.2	156.6	129.2	116.2	116.2	80.0
24	69.6	69.6	74.7	74.7	74.7	77.3	116.2	156.6	129.2	116.2	116.2	80.0
25	69.6	69.6	74.7	74.7	74.7	80.0	116.2	156.6	129.2	116.2	116.2	80.0
26	69.6	69.6	74.7	74.7	74.7	80.0	116.2	156.6	129.2	116.2	116.2	80.0
27	69.6	80.0	74.7	74.7	80.0	77.3	116.2	156.6	129.2	116.2	91.2	80.0
28	69.6	85.5	74.7	74.7	77.3	77.3	129.2	156.6	129.2	116.2	91.2	80.0
29	69.6	.....	74.7	74.7	74.7	77.3	129.2	156.6	129.2	116.2	91.2	80.0
30	69.6	.....	74.7	74.7	74.7	85.5	129.2	156.6	129.2	116.2	91.2	80.0
31	69.6	.....	74.7	.....	74.7	.....	129.2	156.6	.....	116.2	.....	80.0
Average.	70.8	70.5	77.1	75.0	75.0	77.7	100.2	149.2	127.5	117.0	112.2	85.0

Estimated monthly discharge of Skaneateles outlet at Willow Glen weir, including diversion for supply of Syracuse.

[Drainage area, 74 square miles.]

Month.	Mean discharge in second-feet.	Run-off.	
		Second-feet per square mile.	Depth in inches
1901.			
July	142.6	1.93	2.22
August	114.0	1.54	1.78
September	101.6	1.38	1.54
October	117.3	1.58	1.82
November	121.2	1.63	1.82
December	100.3	1.35	1.56
1902.			
January	88.6	1.20	1.38
February	88.5	1.19	1.34
March	96.1	1.30	1.50
April	94.5	1.28	1.43
May	94.5	1.28	1.48
June	95.5	1.29	1.44
July	119.2	1.67	1.93
August	168.5	2.28	2.63
September	146.6	1.98	2.21

Actual run-off of Skaneateles outlet at Willow Glen weir, 1902, in second-feet.

January	70.8	July	100.2
February	70.5	August	149.5
March	77.1	September	127.7
April	75.0	October	117.3
May	75.0	November	112.5
June	77.7	December	87.6

SENECA RIVER AT BALDWINSVILLE, N. Y.

This gaging station was established November 3, 1898, and is described in Water-Supply Papers No. 36, pages 183 to 184, and No. 55, pages 128 to 131, where also the estimated daily discharge and monthly run-off for preceding years may be found.

Mean daily flow, in second-feet, of Seneca River at Baldwinsville, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3,922	2,755	4,414	6,580	3,738	1,753	2,057	4,078	2,540	2,353	2,441	2,785
2	3,977	1,504	6,017	6,341	3,371	2,717	2,045	4,008	2,628	1,980	2,529	2,576
3	4,080	2,929	8,110	6,080	3,490	2,700	2,148	3,440	2,224	2,098	2,896	2,561
4	3,489	2,227	8,399	6,039	2,540	2,551	1,434	3,983	2,162	2,001	2,770	2,503
5	2,747	2,214	8,920	5,704	3,408	1,717	1,867	3,965	2,138	1,264	2,199	2,511
6	3,656	2,231	9,408	4,700	3,224	1,765	1,799	3,870	1,927	3,498	2,593	2,419
7	3,754	2,312	8,995	5,527	3,223	2,356	2,406	3,676	1,141	2,197	2,574	1,867
8	3,529	2,212	9,051	5,459	3,244	1,710	2,759	3,509	2,408	2,146	2,643	2,723
9	3,776	1,517	8,800	5,314	3,264	2,853	2,931	3,533	1,955	2,180	2,383	2,089
10	3,875	2,590	9,374	5,454	3,126	2,087	3,067	3,207	1,874	2,188	2,834	1,977
11	3,838	2,479	9,349	5,569	2,135	2,443	3,344	3,790	1,809	2,188	2,679	1,816
12	2,965	2,429	9,081	5,468	3,523	2,600	3,268	3,643	1,863	1,398	2,263	1,871
13	3,645	2,656	9,407	4,700	2,963	2,516	2,580	3,589	1,805	2,196	2,424	1,786
14	3,172	2,726	9,237	5,535	2,551	2,270	3,285	3,463	1,213	2,223	2,594	1,251
15	3,023	2,527	9,238	5,409	2,444	1,631	3,311	3,266	2,073	2,133	2,476	1,967
16	2,605	1,979	8,422	5,349	2,567	2,750	3,127	3,276	1,951	2,292	1,946	1,338
17	3,090	2,599	9,330	5,444	2,650	2,780	2,960	3,640	1,921	2,041	2,830	1,795
18	3,045	2,513	9,492	5,240	1,657	2,630	2,770	3,169	1,355	2,748	2,612	1,817
19	2,172	2,655	9,033	5,173	2,799	2,606	2,648	3,074	1,847	1,420	1,982	2,114
20	3,192	2,411	8,802	4,496	2,514	2,533	1,979	3,097	1,709	2,671	2,626	2,061
21	2,986	2,363	8,699	5,454	2,506	2,315	2,695	2,926	1,146	2,353	2,743	1,920
22	3,259	2,080	7,923	4,501	1,662	1,737	2,672	2,825	2,213	2,217	2,292	2,786
23	3,120	1,457	8,217	4,480	2,654	2,641	3,210	2,597	1,841	2,286	2,858	3,356
24	3,092	2,387	8,391	4,318	2,705	2,301	3,041	1,999	1,887	2,331	2,917	2,789
25	3,156	2,417	8,074	4,165	2,075	2,102	3,527	2,977	1,603	2,337	2,597	1,477
26	2,009	2,010	8,936	3,792	3,441	2,209	3,538	2,678	1,545	1,729	1,941	2,848
27	3,499	2,650	7,902	3,474	2,805	2,146	2,974	2,509	1,621	2,432	2,612	2,040
28	2,969	2,822	7,667	4,232	2,785	2,001	3,802	2,370	1,296	2,401	2,887	2,375
29	3,041	.....	7,463	3,868	2,640	1,364	3,931	2,378	1,977	2,475	2,488	3,251
30	2,854	.....	6,516	3,881	2,389	2,123	3,843	2,327	1,785	2,312	2,631	3,091
31	2,854	.....	6,966	.....	2,663	.....	3,795	1,686	.....	2,435	.....	3,048

Estimated monthly discharge of Seneca River at Baldwinsville, N. Y.

[Drainage area, 3,103 square miles.]

Month.	Mean discharge in second-feet.	Run-off	
		Second-feet per square mile.	Depth in inches.
1902.			
January	3,279	1.06	1.22
February	2,341	.75	.79
March	8,375	2.70	3.11
April	5,056	1.63	1.82
May	2,788	.90	1.04
June	2,264	.73	.81
July	2,864	.92	1.06
August	3,114	1.00	1.15
September	1,848	.60	.67
October	2,210	.71	.82
November	2,539	.82	.91
December	2,252	.72	.83
The year	3,245	1.04	14.22

ONEIDA RIVER AT OAK ORCHARD, N. Y.

Oneida River forms the outlet of Oneida Lake and joins Seneca River at Three River Point to form Oswego River. Owing to the large surface storage in Oneida Lake and in other lakes and swamps within the watershed, the flow of the stream is unusually regular. There are two low dams in the stream; the one farther downstream at Oak Orchard is a State dam, having a lock at one end; the upper dam at Caughdenoy consists of five W-shaped barriers or eel weirs producing a combined fall of 5 feet during low water. Navigation in the stream is maintained by a lock around one end of the weirs. During extreme high water, the dams at Oak Orchard and Caughdenoy become entirely submerged. There is a dam 8 feet high at Phœnix on Oswego River, 4 miles below the mouth of Oneida River, and it is believed that backwater from this dam produces a smooth surface curve in Oswego and Oneida Rivers from Phœnix to Oneida Lake during extreme freshets. The gaging station was established at Oak Orchard August 30, 1902. The gage readings are taken from a bulkhead of the State lock, upstream from the dam, in order to avoid as much as possible the effect of backwater at ordinary stages until its extent can be more definitely ascertained. Gage readings are taken twice daily at 7 a. m. and 6.30 p. m. by Arthur McArthur.

scharge measurements are made at Schroeppel's bridge 0.4 of a mile low the dam. The bridge has five spans. The current is smooth d relatively deep and the stream bed regular and fairly permanent. ie bridge spans are subdivided into smaller sections during low ater by abandoned bridge piers underneath. A current-meter dis- arge measurement by R. E. Horton, July 22, 1902, gave the fol- wing results: Gage height, 2.75 feet; discharge, 3,307 second-feet.

ean daily gage height, in feet, of Oneida River at Oak Orchard, N. Y., for 1902.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
.....	.....	4.13	4.50	4.05	4.10	17	.....	4.40	4.50	4.00	4.00
.....	.....	4.13	4.58	4.00	4.10	18	.....	4.40	4.50	3.95	3.90
.....	.....	4.13	4.50	4.05	4.05	19	.....	4.40	4.45	4.05	3.85
.....	.....	4.23	4.50	4.05	4.00	20	.....	4.40	4.40	4.05	3.70
.....	.....	4.33	4.45	4.05	4.05	21	.....	4.50	4.40	4.15	3.60
.....	.....	4.20	4.55	4.05	4.10	22	.....	4.58	4.38	4.20	3.55
.....	.....	4.20	4.50	4.08	4.10	23	.....	4.58	4.33	4.15	3.40
.....	.....	4.20	4.50	4.00	4.40	24	.....	4.50	4.30	4.10	3.25
.....	.....	4.20	4.40	4.05	4.20	25	.....	4.50	4.40	4.10	3.20
.....	.....	4.25	4.40	4.10	4.05	26	.....	4.50	4.23	4.10	3.10
.....	.....	4.30	4.40	4.05	4.05	27	.....	4.50	4.35	4.15	3.20
.....	.....	4.30	4.40	4.08	4.00	28	.....	4.60	4.30	4.20	3.20
.....	.....	4.30	4.45	4.10	4.00	29	.....	4.63	4.30	4.15	3.15
.....	.....	4.40	4.55	4.05	4.00	30	4.00	4.58	4.10	4.15	3.15
.....	.....	4.40	4.50	4.10	4.00	31	4.05	.....	4.10	.....	3.25
.....	.....	4.40	4.53	4.10	4.00						

OSWEGO RIVER AT FULTON, N. Y.

During the freshet of March, 1902, a series of observations of the lepth on crest of the lower water-power dam on Oswego River at 'ulton was taken by O. C. Breed, C. E. The dam has a horizontal rest 521 feet in length. The discharge has been calculated by the veir formula, using coefficients adapted to the cross section in ques- ion, selected from the United States deep waterways experiments on lams at Cornell University. On days when water wheels were run- ning at the time of the gage height observations, the amount of water carried around the dam in headraces has been added to the flow from the spillway, the proper allowance having been determined by obser- vations during low water of 1900. The drainage area above the dam is 4,916 square miles.

Discharge of Oswego River at Fulton, N. Y.

Date.	Time.	Discharge.	Run-off
1902.		Second-feet.	Second-feet per square mile
March 2	9 a. m	a 10,200	
Do	5 p. m	13,700	
March 8	7 a. m	19,300	
Do	(?) p. m	19,700	
March 9	9 a. m	18,000	
March 10	10 a. m	18,700	
March 13	12 m	21,400	
March 16	10 a. m	20,215	
March 17	8 a. m	21,100	
March 23	10 a. m	19,400	
March 30	9 a. m	15,500	

a Ice went off from pond above dam.

OSWEGO RIVER ABOVE MINETTO, N. Y.

This gaging station is described and daily elevation of water surface for 1900 and 1901 is given in Water-Supply Paper No. 65, pages 134 to 136. The cable way from which discharge measurements are made is situated three-fifths of a mile below Battle Island dam. The gage, from which observations are taken twice each day by H. L. Woodcock, is 2,930 feet upstream from the cable.

Mean daily flow, in second-feet, of Oswego River above Minetto, N. Y.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1900.					1900.				
1		1,620	2,280	6,080	17	1,998	2,136	2,632	
2		1,620	2,280	5,819	18	1,620	2,040	2,472	
3		1,620	1,552	6,448	19	1,518	2,040	2,424	
4		1,704	1,552	6,448	20	1,662	2,472	2,998	
5		1,704	2,184	10,644	21	1,746	1,280	2,998	
6		1,704	2,424	12,477	22	1,704	1,830		
7		1,280	2,520	12,477	23	1,956	2,328		
8		1,348	2,472	12,477	24	1,662	1,704		
9		1,914	2,376	12,150	25	1,314	1,704		
10		1,704	2,280	11,714	26	1,518	1,746	2,688	
11		1,872	1,746	11,496	27	1,620	1,746	3,656	
12		1,998	2,688	11,060	28	1,566	1,320	4,586	
13		2,040	2,576	11,060	29	1,586	2,136	5,297	
14	1,586	1,662	2,632	10,748	30	1,552	2,232	6,254	
15	1,586	1,746	2,632	9,917	31		2,376		
16	1,745	1,914	2,576	9,917					

Mean daily flow, in second-feet, of Oswego River above Minetto, N. Y.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
	5,297	6,540	2,856	18,190	17,475	7,792	6,724	2,856	2,744	2,968	3,080	4,508
	4,820	5,906	3,336	18,080	16,990	7,792	6,540	2,688	2,744	2,856	3,272	4,359
	4,586	5,210	3,862	18,550	16,174	7,792	6,264	2,688	2,856	2,912	3,024	4,288
	4,430	4,976	4,075	18,190	15,832	7,297	6,080	2,472	3,024	3,144	2,968	4,288
	5,132	4,820	3,862	18,190	15,377	6,816	5,906	2,632	3,144	3,144	2,856	4,359
	4,217	4,742	3,656	18,300	14,925	6,540	5,732	2,744	3,144	2,744	3,024	4,288
	4,359	4,508	3,592	18,080	14,812	7,891	5,645	3,272	3,080	2,856	3,080	4,217
	4,508	4,508	4,004	18,425	14,360	6,080	5,471	2,912	3,208	2,912	3,024	4,586
	5,906	4,075	4,288	18,190	13,912	6,080	5,471	2,744	3,400	2,912	2,968	5,210
	5,384	2,472	4,508	18,080	13,464	6,264	5,471	2,688	3,336	3,024	3,272	5,297
	5,993	3,336	4,508	18,550	12,804	6,264	4,976	2,688	3,272	3,208	3,400	5,645
	6,172	3,464	4,820	18,550	12,368	6,356	5,054	3,080	3,336	2,912	3,336	6,264
	6,448	3,336	4,898	18,300	12,041	6,632	5,054	2,688	3,080	2,576	3,464	6,908
	6,540	3,080	5,819	17,890	11,714	7,099	4,146	2,688	3,024	2,968	3,464	11,496
	6,724	3,208	5,993	17,715	11,387	7,297	4,217	2,856	2,632	3,144	3,400	11,387
	7,099	3,208	6,172	17,890	11,169	7,396	4,075	2,800	3,400	3,144	3,791	13,022
	5,993	3,080	6,540	17,955	10,540	7,594	3,933	2,800	3,272	3,208	3,272	13,240	
	5,471	2,912	6,816	18,080	9,608	7,000	3,656	2,800	3,080	3,144	3,336	13,131
	5,297	2,800	9,505	18,675	7,297	6,816	3,528	2,688	3,272	3,272	3,272	13,022
	5,054	2,800	10,748	19,355	9,198	6,816	3,400	2,520	3,336	2,912	3,336	12,150
	4,508	2,912	13,688	20,066	8,790	6,816	3,144	2,520	3,528	3,272	3,464	11,496
	5,645	2,856	12,368	20,066	7,099	6,816	3,400	2,520	2,968	3,272	3,464	11,605
	5,906	2,968	13,688	19,829	6,908	6,816	3,336	2,688	3,336	4,288	3,592	11,823
	5,645	3,080	13,688	19,948	6,908	7,000	3,400	2,744	2,968	2,912	4,146	12,259
	5,297	3,208	17,955	20,066	6,816	7,099	3,208	2,632	3,080	4,288	4,359	12,368
	5,132	2,800	19,118	19,829	6,816	6,816	3,272	3,144	2,744	3,208	4,508	12,586
	4,820	3,144	18,800	19,829	7,000	7,891	3,272	3,024	2,968	3,024	5,132	12,477
	5,558	2,744	20,540	19,829	7,000	13,576	3,400	3,272	3,464	3,080	5,297	11,932
	5,819	.....	20,777	19,000	7,198	7,198	3,400	3,144	2,632	3,080	5,645	12,695
	5,906	.....	20,303	18,080	7,198	6,816	3,144	3,024	2,856	3,208	5,819	11,823
	6,080	.....	19,711	.....	6,816	.....	2,968	3,208	.....	3,080	.....	11,169

Mean daily flow, in second-feet, of Oswego River above Minetto, N. Y.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	De
1902.												
1	10,956	7,396	8,690	15,718	8,890	6,080	7,396	8,390	4,742	3,656	5,691	5,7
2	10,124	7,297	14,699	15,151	8,790	6,172	7,891	7,297	4,742	3,983	5,732	5,5
3	10,644	7,198	19,237	14,812	8,690	6,080	8,290	8,290	4,586	4,004	5,732	5,5
4	10,332	7,396	19,000	14,586	8,190	5,993	8,290	8,190	4,586	4,298	5,732	5,5
5	10,020	7,297	18,900	14,473	8,390	5,993	8,590	8,090	4,430	4,004	5,732	5,6
6	10,020	7,099	19,237	14,024	8,090	5,993	8,290	8,090	4,298	4,146	5,691	5,5
7	10,124	5,210	19,000	14,248	7,792	5,906	8,790	8,290	1,416	4,146	5,732	5,5
8	10,228	7,000	18,550	13,912	7,396	5,732	8,790	7,891	4,004	4,298	5,906	6,0
9	10,332	6,908	19,000	13,800	6,908	6,264	8,690	7,990	1,348	4,298	4,505	6,0
10	10,020	6,908	19,000	13,576	6,908	6,356	8,690	8,290	1,620	4,298	5,851	6,0
11	9,711	6,632	19,355	13,464	6,448	6,448	8,590	8,690	1,586	4,298	5,906	6,2
12	9,917	6,816	19,829	13,240	6,724	6,540	8,490	8,590	1,518	4,004	5,732	6,2
13	9,814	6,908	21,518	13,131	6,632	6,816	8,490	7,990	1,620	4,146	5,732	6,2
14	9,711	6,724	21,518	12,913	6,540	6,540	8,290	7,990	1,484	4,298	5,556	5,9
15	8,990	6,540	21,400	12,804	6,356	6,264	8,090	7,693	1,552	4,298	5,471	5,9
16	8,790	6,540	19,948	12,695	6,172	6,448	7,792	7,693	1,552	4,586	4,888	5,9
17	8,390	6,724	20,066	12,695	5,906	6,540	7,696	7,198	1,620	4,742	5,732	6,0
18	8,390	6,724	20,540	12,477	5,132	6,356	8,290	7,396	3,862	4,742	5,906	5,9
19	8,190	6,540	20,185	12,041	5,558	6,264	6,816	6,632	3,983	4,430	6,094	5,9
20	7,495	5,054	20,308	10,852	5,132	6,080	7,297	6,540	3,862	4,586	6,080	5,9
21	6,816	4,820	19,829	11,278	4,898	6,172	7,099	6,264	3,400	4,298	6,080	6,0
22	7,396	4,430	19,711	11,060	4,820	5,906	7,099	5,993	3,464	4,064	6,219	6,0
23	5,819	4,430	19,000	10,748	4,586	6,080	7,495	5,906	3,464	5,210	5,993	5,9
24	7,891	4,508	18,425	10,436	4,586	6,172	7,891	5,645	3,464	5,384	6,264	5,9
25	7,693	4,586	17,955	10,228	4,359	6,264	7,792	5,645	3,336	5,556	6,264	5,9
26	7,594	4,586	17,600	10,020	6,632	6,356	8,090	5,558	3,336	5,556	6,264	5,7
27	7,297	4,898	17,230	8,690	6,540	6,172	8,190	4,976	3,336	5,556	6,172	5,7
28	7,099	7,495	16,516	9,093	6,632	5,993	8,290	5,210	2,968	5,556	6,094	6,0
29	7,297	.....	16,060	9,093	6,724	6,080	8,290	5,054	3,272	5,732	5,619	6,0
30	5,906	.....	16,402	9,093	6,816	6,448	8,090	5,054	3,336	5,732	5,645	6,0
31	7,396	.....	16,060	.....	6,356	.....	7,891	4,430	.....	5,732	.....	6,0

Estimated monthly discharge of Oswego River above Minetto, N. Y.

[Drainage area, 4,990 square miles.]

Month.	Mean discharge.	Run-off.	
		Second-feet per square mile.	Depth in inches.
1900.	*Sec.-ft.*		
ptember	1,644	0.32	0.36
ctober	1,823	.36	.41
ovember	2,797	.56	.62
ecember	9,465	1.89	2.18
1901.			
nuary	5,475	1.09	1.26
ebruary	3,667	.73	.76
arch	9,499	1.90	2.19
pril	18,721	3.74	4.17
ay	10,967	2.19	2.52
une	7,215	1.44	1.61
uly	4,428	.88	1.01
ugust	2,813	.56	.64
eptember	3,097	.62	.69
ctober	3,118	.62	.84
ovember	3,668	.73	.81
ecember	9,158	1.83	2.11
The year	6,819	1.36	18.61
1902.			
anuary	8,722	1.64	1.89
ebruary	6,238	1.25	1.31
March	18,540	3.71	4.28
April	12,345	2.47	2.76
May	5,567	1.31	1.51
June	6,216	1.24	1.38
July	8,056	1.61	1.86
August	6,998	1.40	1.61
September	3,057	.61	.68
October	4,648	1.16	1.08
November	5,797	.94	1.29
December	5,116	1.02	1.18
The year	7,608	1.53	20.83

Current-meter discharge measurements of Oswego River at cable station.

Date.	Hydrographer.	Elevation of water surface.	Discharge.
1902.		Feet.	Sec.-ft.
August 19	E. C. Murphy	87.34	6 [illegible]
Do	do	87.44	6 [illegible]
July 21	R. E. Horton	87.87	[illegible]
July 9	E. C. Murphy	88.37	[illegible]
Do	do	88.41	9.4[illegible]
July 8	do	88.42	[illegible]
Do	do	88.44	[illegible]
April 1	do	91.52	13.6[illegible]
March 31	do	91.77	15.9[illegible]

A rating curve for the cross section at the cable station has been plotted from the above discharge measurements and those previously made and the daily discharge and run-off calculated as given in the accompanying tables. No allowance for water diverted to Oswego Canal has been made. It is the intention, however, to make a series of measurements of the flow in this canal.

March 13 at 5 p. m. the stream reached an elevation of water surface of 94.45 corresponding to a discharge of about 22,500 second-feet, or 4.5 second-feet per square mile. The ice flowed out of the level in which the cable is situated March 7.

OSWEGO RIVER AT HIGH DAM, NEW YORK.

This gaging station is described and the mean daily discharge and run-off for 1897 to 1901, inclusive, are given in Water-Supply Paper No. 65, pages 137 to 139. Owing to the irregular and uncertain condition of flashboards on the dam it has been impossible to calculate the discharge for the year 1902 in a reliable manner, and the record is withheld until additional information can be secured. A current-meter discharge measurement of the flow in the headrace at the dam was made July 21, 1902; all water wheels were running and the measured flow was 650 second-feet, the effective head on the turbines being 13 feet.

ST. LAWRENCE RIVER DRAINAGE BASIN.

RAQUETTE RIVER AT HANNAWA FALLS, N. Y.

The watershed of this stream is described in Water-Supply Paper o. 65, pages 36 to 38. A gaging record at the dam of the Hannawa alls Water Power Company has been kept, beginning September 1, 02. The record includes the depth flowing over the crest of the am, the number of hours run, and width of gate opening of each of e two pairs of water wheels in use. The nominal working head is feet. A record of the height of the water in the forebay and also the tailrace is kept, from which the variations in the effective head an be determined for the purpose of calculating the discharge through e turbines. The height of opening of the waste gates used for log uicing and freshet control at the dam, and of the overflow gate at ie entrance to the power canal is also recorded.

RICHELIEU RIVER AT FORT MONTGOMERY, N. Y.

Richelieu River, the outlet of Lake Champlain, leaves the lake at ouse Point near the international boundary between New York and anada. A record of the daily stage of the lake at its outlet has been ept since January 1, 1875. Data for reducing the observed elevation f water surface to equivalent discharge in the outlet were obtained y the United States Board of Engineers on Deep Waterways at the hambly dam in 1898. The resulting calculated monthly mean flow nd other discharge data are to be found in Water-Supply Paper No. 5, pages 38 to 42. Through the courtesy of Capt. Harry Taylor, . S. Army, the gage readings taken daily are reported each week to ie United States Geological Survey.

The gage readings are taken by measuring with a rod the depth of ater on the base of the scarp wall of the north bastion of Fort Montomery about 3 feet from the angle with the east curtain of the fort. he elevation of this datum is 95 feet above tide. The gage readigs are referred to a datum 1.5 feet lower; 1.5 feet being added to he measured depth to obtain the recorded gage height.[a] During inter, when the lake is frozen over, the gage height is measured in n open well, which does not freeze, situated within the fort inclosure.

[a] The gage zero elevation, 93.50 above mean tide at New York, is the lowest recorded stage of ie lake.

Mean daily flow, in second-feet, of Richelieu River at Fort Montgomery, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	De-
1902.												
1	13,240	11,460	10,610	37,400	26,440	22,180	18,660	14,740	11,630	9,080	10,[illegible]	[illegible]
2	13,980	11,460	12,160	36,700	26,180	21,700	18,450	15,120	11,290	8,570	10,950	[illegible]
3	13,240	11,460	15,880	36,350	26,440	21,040	18,660	14,930	11,290	8,740	11,290	[illegible]
4	13,240	11,460	19,500	36,000	26,180	17,820	18,240	14,380	10,440	8,400	10,950	[illegible]
5	13,600	11,630	21,260	35,340	25,920	21,260	18,030	14,170	10,270	8,910	10,950	[illegible]
6	13,240	11,460	22,180	35,010	25,140	21,040	17,610	14,550	10,610	8,570	11,980	[illegible]
7	13,240	11,460	22,660	34,350	26,700	21,480	18,450	14,360	11,290	9,420	10,950	[illegible]
8	12,880	11,290	22,660	33,360	25,140	20,160	17,820	13,980	10,440	8,570	10,440	[illegible]
9	12,880	11,290	23,140	31,770	24,100	20,380	17,400	14,170	10,950	8,400	10,6[illegible]	[illegible]
10	12,700	11,290	23,380	32,360	23,380	20,380	16,640	14,170	10,100	8,400	10,100	[illegible]
11	12,520	11,120	23,620	32,360	23,620	20,600	16,260	14,360	10,780	9,420	10,270	[illegible]
12	12,520	11,120	23,620	32,080	23,140	20,160	17,400	13,790	10,270	8,080	12,160	[illegible]
13	12,700	10,950	25,140	32,360	22,660	20,380	16,450	13,600	[illegible]	9,080	10,440	[illegible]
14	12,340	10,950	27,860	32,080	21,700	19,940	16,070	13,790	9,930	8,230	10,100	[illegible]
15	12,520	10,950	29,910	31,770	21,700	20,820	15,880	13,420	10,270	8,910	10,950	[illegible]
16	12,340	10,780	[illegible]	31,150	21,700	20,380	15,310	13,420	10,100	8,080	10,440	[illegible]
17	11,980	10,780	31,460	30,220	21,040	21,040	16,070	13,060	10,100	8,230	10,440	[illegible]
18	12,160	10,780	34,020	29,910	20,600	21,260	15,120	12,880	12,160	8,570	11,290	[illegible]
19	11,630	10,610	35,010	29,910	20,380	21,700	15,310	12,880	9,930	8,570	11,120	[illegible]
20	11,630	10,610	35,340	29,310	19,500	21,040	15,120	12,700	9,590	8,400	10,780	[illegible]
21	11,460	10,440	35,340	28,440	19,720	21,040	15,500	13,600	9,930	7,890	11,120	[illegible]
22	11,290	10,270	36,000	29,020	19,290	21,040	15,120	12,880	10,100	8,570	11,120	[illegible]
23	11,630	10,270	36,700	28,440	18,870	20,380	15,310	12,340	9,930	7,550	10,270	[illegible]
24	11,460	10,270	37,050	27,860	18,240	20,380	15,310	12,160	9,080	10,100	11,290	[illegible]
25	11,460	10,100	37,050	27,570	18,660	19,940	15,500	11,980	9,250	7,720	10,100	[illegible]
26	11,630	10,100	36,700	29,020	18,870	20,160	15,690	12,340	9,930	8,570	10,100	[illegible]
27	11,630	10,100	37,400	27,280	18,870	19,500	15,690	11,980	9,420	9,250	10,950	[illegible]
28	11,460	10,100	37,050	26,700	19,940	19,080	15,120	11,800	9,250	8,080	10,440	[illegible]
29	11,630	[illegible]	36,350	26,700	21,940	18,870	14,930	11,980	8,740	8,570	10,780	[illegible]
30	11,460	[illegible]	36,000	27,570	21,040	19,080	14,740	11,800	8,910	9,760	10,780	[illegible]
31	11,460	[illegible]	37,050	[illegible]	21,700	[illegible]	14,740	11,460	[illegible]	9,760	[illegible]	[illegible]
Mean	12,295	10,877	28,700	31,282	22,212	20,474	16,338	13,315	10,206	8,657	10,77[illegible]	[illegible]

timated monthly discharge of Lake Champlain drainage basin at Chambly, Province of Quebec.

[Drainage area, 7,750 square miles.]

Month.	Mean discharge.	Run-off.	
		Second-feet per square mile.	Depth in inches.
1902.	*Second-feet.*		
nuary	12,295	1.59	1.83
bruary	10,877	1.40	1.42
arch	28,700	3.70	4.27
pril	31,282	4.04	4.51
ay	22,212	2.87	3.31
ne	20,474	2.64	2.95
ly	16,338	2.11	2.43
ugust	13,315	1.72	1.98
ptember	10,206	1.32	1.47
ctober	8,657	1.12	1.29
ovember	10,777	1.39	1.55
ecember	10,405	1.34	1.54
The year	16,299	2.10	28.55

MOHAWK RIVER DRAINAGE BASIN.

ORISKANY CREEK NEAR ORISKANY, N. Y.

This gaging station was established at Wood road bridge, 1 mile bove Oriskany village, June 25, 1901, taking the place of a station reviously maintained at the New York State dam at Oriskany. Both tations are described and records given for preceding years in Water-upply Paper No. 65, pages 145 to 149.

urrent-meter discharge measurements of Oriskany Creek at Wood road bridge.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
eptember 9	C. C. Covert	2.00	275
larch 3	R. E. Horton	5.12	2,125

March 1, 1902, the calculated discharge over the Waterbury dam at Oriskany was 5,200 second-feet, the gage reading at Wood's bridge being 8.26 feet. This was taken after the ice floe passed downstream.

The calculated maximum discharge of Oriskany Creek during the freshet of December 15–16, 1901, was 7,350 second-feet, or 51.4 second-feet per square mile.

Mean daily gage height, in feet, of Oriskany Creek near Oriskany, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.70	3.20	8.00	2.60	1.85	1.80	2.50	2.50	1.50	2.50	2.30	2.1
2	4.40	3.00	7.00	2.90	1.80	1.60	2.10	2.90	1.95	2.70	2.35	2.
3	4.70	3.00	6.00	3.10	2.05	2.15	2.70	2.40	2.20	2.05	2.35	2.4
4	4.45	3.50	4.80	2.75	2.40	3.05	3.30	2.30	2.75	1.70	2.35	2.
5	4.00	3.40	3.45	2.70	1.90	2.50	4.30	2.00	2.15	1.70	2.30	2.1
6	3.90	3.20	2.95	2.60	1.90	2.05	3.60	3.70	1.70	2.20	2.35	2.3
7	3.85	3.05	2.90	2.50	1.90	2.00	3.50	3.10	1.95	2.30	2.30	2.
8	3.80	3.00	2.70	2.40	1.80	2.40	3.20	3.25	1.65	2.15	2.00	2.
9	3.60	3.00	2.60	2.55	1.80	3.10	2.90	2.40	1.80	2.00	2.00	2.
10	3.40	2.80	2.75	3.25	1.75	3.50	3.75	2.05	2.20	1.80	1.90	2.0
11	3.60	2.80	3.00	2.70	1.65	3.10	2.80	2.45	1.90	1.65	2.15	2.
12	3.15	3.10	6.10	2.45	1.60	2.70	2.40	2.25	1.70	1.65	2.30	2.
13	2.80	3.10	6.05	2.70	1.60	2.20	2.00	2.00	1.40	1.80	2.35	2.
14	2.60	3.10	4.90	2.65	1.60	2.25	1.80	2.00	1.40	1.80	2.30	2.0
15	2.60	3.10	3.90	2.40	1.00	2.25	2.70	1.80	1.60	1.65	2.05	2.
16	2.00	3.10	4.15	2.40	1.20	2.00	2.60	1.60	1.60	1.65	1.95	2.0
17	3.00	3.10	5.80	2.40	1.20	1.90	2.25	1.75	1.60	1.60	2.05	2.1
18	2.70	3.10	4.70	2.30	1.40	1.85	1.90	2.10	1.70	1.60	2.25	2.
19	2.00	3.10	4.00	2.20	1.50	2.00	2.25	2.50	1.60	2.25	2.15	2.
20	2.60	3.10	3.05	2.20	1.85	1.90	2.50	2.10	1.40	2.10	1.80	2.0
21	2.80	3.15	3.20	2.20	1.60	2.00	4.00	2.10	1.55	2.20	1.95	2.1
22	3.70	3.20	3.15	2.10	1.40	1.90	3.90	2.50	1.60	1.95	1.90	2.0
23	3.45	3.20	3.20	2.00	1.25	2.00	3.25	2.70	1.50	2.30	1.70	2.0
24	3.20	3.20	3.25	1.90	2.00	2.00	2.80	2.15	1.60	2.15	2.05	2.0
25	3.20	3.40	3.00	1.80	1.90	1.80	2.55	1.90	1.60	1.80	2.25	2.
26	3.25	3.45	2.80	1.90	2.90	2.10	2.25	1.60	1.90	1.80	2.30	2.
27	3.65	3.90	2.70	1.90	2.85	2.00	1.90	1.45	1.50	2.00	2.35	2.0
28	3.60	5.00	2.70	1.90	2.75	1.85	2.60	1.85	1.60	5.10	2.40	2.2
29	3.60	.....	3.05	1.90	2.80	1.85	2.70	1.70	1.95	3.50	2.45	2.1
30	3.50	.....	2.90	2.00	3.20	2.25	2.35	1.55	2.20	2.80	2.20	2.
31	3.40	.....	2.70	.....	2.70	.....	2.30	1.45	.....	2.90	.....	1.9

MOHAWK RIVER AT UTICA, N. Y.

This gaging station is described in Water-Supply Paper No. [illegible] pages 151 to 153. March 1 and 2, 1902, a freshet occurred, accompanied by the breaking up of the winter's ice accumulation, which raised the water to elevation 407.14, the estimated discharge being 17,200 second-feet from the drainage area of 500 square miles, or 34. second-feet per square mile.

Mean daily flow, in second-feet, of Mohawk River at Utica, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	536	283	11,750	.....	1,972	.....	1,618	408	383	589	1,585	870
	631	484	11,150	1,264	771	.....	1,972	1,900	383	743	743	785
	617	420	10,300	1,652	562	.....	2,009	.....	270	575	743	960
	484	420	6,800	1,295	.....	.....	.....	433	270	484	673	2,085
	.....	445	4,520	1,110	617	1,900	3,542	1,140	445	445	659	1,486
	510	445	3,840	1,140	523	743	.....	1,295	.....	510	645	687
	471	420	1,990	1,020	523	510	.....	2,200	.....	945	1,080	715
	471	420	1,810	900	562	673	2,688	1,520	.....	1,283	743	900
	471	433	1,658	900	370	1,050	1,619	1,520	[a]35	729	575	813
	433	420	1,155	2,065	320	631	1,828	.....	1,282	484	458	701
	433	701	.....	1,864	.....	1,775	1,810	715	645	458	589	841
	395	420	3,200	1,186	270	1,065	870	1,536	[a]69	458	645	729
	345	420	5,395	1,110	.....	1,264	701	757	370	484	1,050	.....
	358	420	4,700	1,005	320	1,080	645	617	345	471	757	549
	408	445	3,542	870	295	.....	980	523	715	471	631	617
	408	445	3,060	729	295	.....	1,810	484	510	458	631	645
	283	433	4,640	659	220	549	1,586	.....	484	383	562	.....
	370	433	.....	589	208	549	870	471	562	395	562	2,661
	370	433	3,025	497	308	.....	701	484	562	.....	589	2,920
	370	433	2,085	458	433	484	2,085	523	562	1,900	701	2,850
	395	433	1,295	484	283	.....	2,767	484	471	.....	603	2,066
	420	445	1,390	438	245	.....	3,684	484	458	.....	645	2,220
	1,050	445	1,864	458	245	900	3,200	484	484	.....	975	3,390
	1,050	471	1,705	.....	585	549	1,825	.....	220	.....	900	.....
	562	471	1,342	270	.....	484	1,005	484	220	.....	799	2,520
	673	538	1,140	383	1,520	960	813	395	245	562	617	1,486
	729	1,828	1,050	536	2,085	2,180	.....	471	245	631	.....	1,020
	729	.....	1,020	562	1,085	1,536	1,687	420	320	3,200	2,085	.....
	785	.....	1,342	270	1,110	.....	1,653	383	1,060	4,100	1,232	813
	673	.....	2,240	1,520	1,202	1,569	715	383	743	3,095	855	757
	510	.....	1,279	.....	701	.....	433	383	.....	1,586	.....	799

[a] Below limit of rating curve.

Current-meter discharge measurements of Mohawk River at Utica, N. Y.

Date.	Elevation of water surface.	Discharge.	Hydrographer.
1902.	*Feet.*	*Sec.-ft.*	
March 4	405.96	11,678	R. E. Horton.
July 1	398.63	2,071	H. R. Beebe.
July 3	400.43	2,589	Do.
July 7	403.11	4,391	Do.
August 22	395.17	454	C. C. Covert.
December 10	395.97	[a]681	R. E. Horton.
December 11	396.47	[a]817	C. C. Covert.

[a] Measured through 6 inches of ice at Schuyler street bridge, Utica, N. Y.

Estimated monthly discharge of Mohawk River at Utica, N. Y.

[Drainage area, 600 square miles.]

Month.	Mean discharge.	Run-off	
		Second-feet per square mile.	Depth in inches
1902.	*Second-feet.*		
January	531	1.06	1.2
February	496	.99	1.0
March	3,475	6.95	7.8
April	902	1.80	2.0
May	651	1.30	1.5
June	1,023	2.04	2.2
July	1,669	3.33	3.8
August	774	1.54	1.7
September	457	.91	1.0
October	1,016	2.03	2.3
November	805	1.61	1.8
December	1,368	2.74	3.1
The year	1,097	2.19	29.9

REELS CREEK NEAR UTICA, N. Y.

Reels Creek is tributary to the Mohawk River from the north at Utica, N. Y. Its drainage basin is shown on the Utica sheet of the United States Geological Survey; the watershed is hilly. The stream receives numerous lateral tributaries, draining deep ravines and entering the main stream at short intervals in a manner conducive to the rapid carrying off of surface waters. The watershed is mostly pasture land, some timber, and a small percentage of cultivated fields. A deep soil of clay and gravel is underlain with loose shale. There is very little swamp or "spring ground." Tributaries which head in the gravel of the serrated hillsides as a rule become dry at times. Others, which have shale beds, are fed by springs of percolating water which has passed through the glacial drift to the rock horizon.

In 1900 a masonry intake dam was constructed on the stream 4 miles north of Utica by the Consolidated Water Company, of Utica. Beginning January 1, 1901, a record has been kept of the wastage at this dam, as well as the diversion for water-supply purposes wherever water has been taken. A record of the precipitation on the watershed has been kept at Deerfield reservoir, 1 mile downstream from the intake dam. The records of rainfall and stream flow have been furnished by William S. Bacot, civil engineer.

The intake dam has a spillway 119.7 feet long, 6 feet in width, and

lope downward on the upstream side of 0.75 foot. The water falls o a masonry pool. In order to determine the low-water flow more :urately than could be done by calculation of the discharge over) rough masonry spillway crest, a standard thin-edged weir was ıstructed on the overflow wall of the water cushion. The weir has :rest 29.02 feet long, with two complete end contractions. The :st is of steel, set perfectly level, and readings of depth are made a hook gage set in a stilling box 6 feet upstream from the weir.

A calculation of the discharge over the main spillway of the intake ın under low heads was made by running constant volumes of water er both the spillway and weir, corresponding to different depths on e spillway, and the data so obtained have been used in reducing the servations taken before the weir was constructed. During the riod from June 1, 1901, to May 1, 1902, the gage was read as a rule .ly once a week. During the remainder of the record the observa-)ns have been taken daily.

There are no dams, ponds, or storage reservoirs above the point of ıging, and the stream receives very little surface contamination. he records are of interest in that they show the natural regimen of small stream of the northern plateau, as well as the sequence of .infall and of run-off in a torrential drainage basin.

The basin formed by the intake dam has a storage capacity of ',000,000 gallons. It is practically always filled and exerts very little ıfluence on the rate of discharge of storm waters. The greatest nown freshet in the stream occurred in August, 1898. Data are not vailable for the calculation of the discharge. It is known to have reatly exceeded any freshet which has occurred while the record has een kept. It is probable that the record does not show the maximum ischarge on March 1 of 1902, as the daily gage reading on that date 'as taken before the flood reached its highest stage. The minimum ow, since the installment of the gaging weir, occurred August 30 to eptember 1, 1902, inclusive, and shows a discharge of 0.4 second-oot from the drainage area of 4.5 square miles, or 0.089 second-foot ıer square mile. The drainage area of the stream above its confluence vith Mohawk River is 8.4 square miles.

Measurements of the flow of Reels Creek at a point 200 feet up-tream from the intake dam, made during 1902, gave the following esults:

Discharge measurements of Reels Creek.

Date.	Time.	Discharge.
1902.		*Second-feet.*
April 26	P. M.	2.4
May 5	P. M.	9.7
May 14	A. M.	1.2

Surface floats were used, and owing to the low velocity and small volume of discharge, they were run through a short section (35 feet).

In this connection may be given the data relative to certain other small watersheds.

The maximum discharge of Ballou Creek, which enters Mohawk River at Utica from the south, is calculated from the observed depth on the spillway and waste gate of the No. 4 reservoir of the Utica Waterworks Company, at 181 second-feet or 130 second-feet per square mile from the tributary drainage of 1.4 square miles above point of gaging. This freshet was caused by a very heavy thunder storm, which raised the water in the reservoir several feet in an hour.

Mean daily flow, in second-feet, of Reels Creek near Utica, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1	1.75	1.75	1.30	1.75	1.75	128.40						
2	1.75	1.75	1.30	15.30	1.75						1.30	
3	1.75	1.75	1.30	35.50	1.75			6.00				
4	1.75	1.30	1.30	38.00	1.30							
5	1.75	1.30	1.30	27.00	1.30					1.75		
6	1.75	1.30	1.30	6.69	1.30		37.50					
7	1.75	1.30	1.30	19.50	1.30				32.00			
8	1.75	1.30	1.30	44.59	1.30	209.10						
9	102.50	1.30	3.12	22.31	1.30						30.50	
10	62.00	1.30	4.38	15.30	2.48			15.30				
11	1.75	1.30	1.75	12.00	6.83							
12	1.75	1.30	1.75	12.00	62.68					1.30		
13	1.75	1.30	1.75	4.50	34.72		9.00					
14	1.75	1.30	1.75	2.48	6.70				1.75			
15	1.75	1.30	1.75	2.48	4.41	9.00						
16	1.75	1.30	3.41	2.48	1.75						1.75	
17	1.75	1.30	2.50	2.48	1.30			4.50				
18	1.75	(a)	3.12	2.48	55.80							
19	1.75		3.44	5.45	3.40					15.30		
20	1.75		4.06	4.87	2.48		1.75					
21	1.75		49.90	1.75	2.48				1.30			
22	1.75		22.80	2.48	1.75	2.48						
23	1.75		12.00	6.00	15.30						1.30	
24	1.30		15.25	2.48	1.75			132.40				
25	1.30		14.62	55.80	1.75					1.30		
26	1.30		10.88	1.75	1.75							
27	1.30		43.55	1.75	2.48		1.30					
28	1.30		24.50	1.75	2.48				1.30			
29	1.30		7.70	1.75	15.30	1.75						
30	1.30		2.48	1.75	15.30						1.30	
31	1.30		1.75		9.00			62.00				
Mean	6.83	1.38	8.02	11.81	8.55	70.15	12.39	44.04	9.09	4.91	7.23	

a Record interrupted.

Mean daily flow, in second-feet, of Reels Creek near Utica, N. Y.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
		1.30	254.70		4.50	10.3	42.5	.9	.4	9.10	3.90	3.90
			167.00		1.30	1.6	2.0	.8	2.2	9.10	2.90	5.40
			92.00		18.60	108.0	128.5	1.5	1.2	7.80	2.60	6.00
	1.80				9.00	42.5	20.6	1.4	2.4	2.90	2.20	3.90
				30.50	13.60	8.4	206.7	1.2	1.5	1.80	2.20	2.20
					12.00	1.1	86.8	5.4	.9	28.50	3.90	2.20
				2.48	9.00	0.9	30.6	9.1	15.4	3.90	2.20	2.40
		1.75	4.50		4.50	26.1	15.4	21.6	2.2	28.50	2.20	5.40
					1.75	4 5	2.2	2.2	1.5	9.40	1.80	5.40
					1.30	3.1	42.5	1.5	71.2	11.30	1.50	5.40
	1.80				1.30	9.1	2.2	2.8	15.4	2.20	1.10	4.40
			126.74	12.00	1.30	42.5	1.5	2.8	2.2	1.50	5.40	4.40
			209.90		1.30	9.1	.9	2.3	1.5	1.50	7.20	4.40
			94.50		1.30	4.3	.8	2.0	1.2	2.20	2.60	4.40
		1.30	9.98		1.30	8.4	.8	1.9	1.1	1.50		4.40
			128.30		1.11	4.5	32.8	2.0	.9	1.10		19.50
			63.30		1.11	2.2	20.6	2.2	.8	29.10	1.80	7.80
	1.80		19.50		1.11	2.1	2.0	2.0	.8	.90	2.90	7.80
			9.51	1.30	1.30	2.7	1.5	5.1	.7	120.80	3.90	10.50
					1.30	1.5	42.5	3.1	.4	9.10	2.60	10.50
				1.30	1.30	7.8	149.5	3.2	1.1	3.90	2.20	10.50
	4.69	1.30	2.48		1.11	2.4	42.5	2.2	1.1	2.90	2.20	12.00
	5.00				(a)	1.7	5.4	.9	.8	6.90	5.40	7.80
				1.30		2.7	2.2	.8	.8	4.90	4.90	6.60
	1.80			1.30		1.4	2.0	.7	.7	1.90	3.90	5.40
				2.48		42.5	1.5	.7	3.8	1.10	4.90	5.40
				30.50		2.0	20.6	.7	1.5	5.40	4.30	5.40
		4.69		3.40		1.5	9.0	.5	1.1	38.20	7.00	5.40
			61.11	1.30		2.4	5.1	.5	7.7	6.00	4.90	4.90
			12.00	42.40		42.5	2.2	.4	9.0	6.00	3.90	4.90
			8.00				1.0	.4		6.00		4.90
Mean	2.48	2.07	78.9	10.85	3.88	13.1	29.8	2.6	5.0	11.78	3.21	6.27

(a) Waste gate opened. Setting weir.

Precipitation, in inches, at Deerfield reservoir, New York.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	De
1901.												
1	0.08					0.57			0.58			
2					0.04							
3				0.45				0.05	.53	0.45		
4		0.42		.34		.27	0.73			.15		
5	.10		0.51				1.48					
6				.04			.09	.55				
7	.10			1.04		1.16	.80					
8			1.00			1.07		.10			0.22	
9	.50			.17		.17		.60			.[illegible]	
10		.23	.25		.10					.30		
11	.05				.25			.07	.70	.03		
12	.02		.07		.62						.[illegible]	
13			.12		.22				.42		1.10	
14			.21						.32	.72		
15	.23		.25					.73	.60		.[illegible]	
16		.40							.61		.[illegible]	
17		.10					.40		.34	.20		
18			.13		.93					.50		
19			.02	.17		.38						
20												
21		.50	.77	.14		1.14						
22	.18					1.07						
23			.07	.56	.57							
24								.40			.[illegible]	
25				.50								
26							.10					
27					.22							
28												
29					.45		.24		.20		.[illegible]	
30				.17	.10			.18	.10			
31	.12				.18		.03					
Total	3.12	1.79	3.09	3.58	4.57	5.73	3.87	2.68	4.50	2.35	2.46	[illegible]

Precipitation, in inches, at Deerfield reservoir, New York—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	.....	.....	1.15	0.12	0.08	.....	.....	.....	.....	0.44	.....	.....
	.....	0.05	1.12	.18	.....	.....	.....	0.41	0.20	.25	.....	.....
	.....	1.25	.08	.08	.44	.....	1.75	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	0.35	.....	.....	.62	.02	.....	0.50
	.....	.....	1.12	.....	.20	.72	1.43	.....	.....	.08	.....	.....
	.....	.....	.....	.....	.....	.....	.35	1.42	.....	.35	0.10	.....
	.....	.08	.....	.....	.29	.....	.08	.....	.65	.....	.....	.15
	.....	.....	.....	.....	.....	.75	.11	.56	.....	.40	.....	.....
	.....	.25	.08	.60	.....	.....	.....	.....	.....	.....	.....	.....
	.....	.08	.....	.....	.....	.68	.42	.05	1.05	.....	.....	.....
	0.08	.02	.65	.....	.....	.....	.....	.71	.....	.....	.....	.....
	.05	.....	.....	.10	.....	.32	.....	.....	.....	.....	.23	.80
	.08	.08	.75	.....	.....	.31	.22	.....	.17	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.30	.....	.....	.20	.....	.....
	.....	.....	.....	.....	.....	.54	.31	.....	.....	.....	.20	.....
	.....	.....	.85	.....	.....	.14	.....	.10	.....	.....	.....	1.30
	.05	.....	.....	.....	.....	.....	.....	.10	.....	.....	.....	.15
	.....	.25	.....	.....	.....	.....	.....	.....	.....	.....	.08	.05
	.05	.....	.....	.....	.65	.32	.60	.46	.....	1.23	.15	.....
	.....	.....	.....	.....	.....	.....	.80	.....	.....	.16	.....	.....
	.25	.....	.....	.07	.....	.52	.....	.48	.24	.....	.....	.40
	.....	.....	.....	.....	.....	.09	1.60	.28	.....	.....	.....	.75
3	.....	.....	.....	.....	.02	.02	.....	.....	.....	.16	.45	.....
4	.....	.....	.....	.....	.50	.32	.15	.....	.03	.07	.....	.05
5	.....	.08	.....	.....	.30	.....	.....	.....	.....	.05	.02	.....
6	.02	.....	.....	.21	.43	.76	.....	.....	.75	.....	.36	.08
7	.55	.....	.....	.05	.....	.09	.62	.10	.....	.51	.45	.11
8	.....	1.00	.30	.....	.35	.34	.43	.....	.....	1.70	.05	.....
9	.....	.....	.12	.....	.....	.68	.....	.....	1.40	.11	.....	.....
0	.08	.....	.10	.77	.72	.....	.....	.....	.70	.....	.02	.....
1	.....	.....	.02	.....	.....	.....	.08	.....	.....	.25	.....	.....
Total	1.06	2.94	6.24	2.13	3.93	6.95	9.15	4.67	5.81	5.93	2.11	4.34

WEST CANADA CREEK AT TWIN ROCK BRIDGE, NEW YORK.

The gaging station at this point was established September 7, 1900. The readings are furnished by the Utica Gas and Electric Company, and are taken twice each day by George Rood. The station is described in Water-Supply Paper No. 65, pages 153 to 155. The record at Twin Rock Bridge replaces one formerly kept at Middleville on the same stream. The record at Middleville from 1898 to 1901 is given in Water-Supply Paper No. 65, pages 155 to 157.

Current-meter discharge measurements of West Canada Creek at Twin Rock Bridge.

Date.	Hydrographer.	Gage height.	Di...
1902.		*Feet.*	
August 25	C. C. Covert	1.25	
June 17	H. R. Beebe	2.34	
Do	do	2.39	
October 10	R. E. Horton	2.74	
June 16	do	2.93	
June 28	do	3.02	
Do	H. R. Beebe	3.45	
June 27	do	4.12	
Do	do	4.52	

Mean daily gage height, in feet, of West Canada Creek at Twin Rock Bridge.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept	Oct	Nov.	D...
1902.												
1	2.00	1.90	4.90	4.75	5.20	2.15	3.10	1.65	1.00	2.80	3.10	
2	2.00	1.90	6.80	3.90	3.95	2.10	3.35	1.50	.90	1.75	2.85	
3	2.00	2.00	7.65	3.15	3.05	1.90	4.90	1.50	.78	1.35	2.35	
4	2.00	2.00	6.40	2.40	3.15	3.25	7.05	1.43	.70	1.20	1.85	
5	2.00	2.00	5.40	2.43	3.50	2.65	4.45	1.28	.90	1.25	1.80	
6	2.00	2.00	4.25	2.80	2.65	1.95	3.60	1.80	1.10	1.23	1.65	
7	2.00	2.00	3.75	2.35	2.75	2.45	2.55	2.50	1.10	1.23	2.25	
8	2.00	2.00	3.30	2.38	2.30	2.10	2.55	2.33	1.45	3.00	2.05	
9	2.00	2.00	3.40	5.45	2.10	1.70	2.42	2.70	1.80	3.30	1.90	
10	2.00	2.00	3.10	5.25	2.10	2.10	2.35	2.65	1.70	2.70	1.65	
11	2.00	2.00	3.08	3.65	1.85	3.13	2.10	2.40	1.55	1.63	1.50	
12	2.00	2.00	3.50	3.43	1.70	2.80	1.53	3.15	1.05	1.40	1.65	
13	2.00	2.00	5.10	3.45	1.45	2.45	1.30	2.40	1.00	1.30	3.10	
14	2.00	2.00	6.85	3.65	1.28	2.25	1.23	1.95	1.15	1.28	3.20	
15	2.00	2.00	5.05	2.75	1.00	2.95	1.80	1.70	1.03	1.90	2.30	
16	2.00	1.90	5.70	2.50	1.00	2.90	4.00	1.45	.90	1.23	2.10	
17	2.00	1.90	8.25	2.60	1.15	2.50	2.40	1.40	.90	1.00	2.35	
18	2.00	1.85	7.00	2.45	1.33	1.90	2.18	1.30	.75	.75	2.15	
19	2.00	1.68	7.25	2.35	1.33	1.63	1.90	1.55	.60	2.25	1.75	
20	2.00	1.60	6.88	2.50	1.45	1.75	2.80	1.48	.50	3.70	1.60	
21	2.00	1.53	3.50	2.25	1.43	1.80	4.13	1.60	.65	4.25	1.70	
22	1.90	1.50	3.20	3.20	1.38	3.65	5.10	1.70	.60	3.80	1.65	
23	1.80	1.90	3.80	2.75	1.30	2.95	4.28	1.68	.60	3.25	2.10	
24	1.80	1.60	3.70	2.50	2.70	2.40	2.95	1.48	.60	3.28	1.45	
25	1.90	1.53	3.43	2.55	3.50	1.90	2.50	1.30	.63	2.20	1.65	
26	1.90	1.63	3.23	2.35	3.23	3.40	1.70	1.13	.73	2.50	1.50	
27	1.90	1.38	3.05	3.10	2.85	4.30	1.43	1.00	1.00	3.00	1.60	
28	1.90	1.85	3.40	3.30	2.60	3.15	1.75	.85	1.20	5.20	2.20	
29	1.90	.....	6.30	2.43	2.50	2.55	1.55	.80	2.50	6.50	2.10	
30	1.90	.....	8.00	4.15	2.80	3.70	1.65	.73	3.45	4.30	1.75	
31	1.90	.....	6.00	.....	3.10	.....	1.45	1.10	.....	4.65	.....	

EAST CANADA CREEK AT DOLGEVILLE, N. Y.

This gaging station was established September 23, 1898. A descrip-on of the drainage basin and recorded run-off for preceding years ay be found in Water-Supply Paper No. 65, pages 158 to 161. The epth on the crest of the dam and readings of the gate opening of rbines are taken twice daily by John M. Kelley.

November 4 to 14 inclusive, 1901, a series of readings at one-half our intervals from 6 a. m. to 6 p. m. was taken for the purpose of necking the discharge as calculated from the readings taken in the sual manner twice daily.

Discharge measurements of East Canada Creek.

Date.	Mean flow estimated from one-half hour observations.	Maximum daily flow.	Minimum daily flow.
1901.	*Sec.-ft.*	*Sec.-ft.*	*Sec.-ft.*
November 4	[a] 83.5	87.5	78
November 5	134.2	192.0	94
November 6	173.4	191.0	149
November 7	164.3	191.0	98
November 8	185.4	192.0	169
November 9	200.8	235.0	145
November 11	136.1	236.0	69
November 12	393.4	835.0	153
November 13	1,222.0	1,288.0	1,185
November 14	844.2	918.0	809

[a] Pond refilling, November 4, during several hours, reducing average outflow for day.

Mean daily flow, in second-feet, of East Canada Creek at Dolgeville, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	De
1902.												
1	241	236	2,541	1,721	1,333	a 373	916	339	.....	69	1,03	
2	241	a 190	a2,620	1,322	881	216	796	334	74	58	a 8	
3	254	236	2,370	1,102	883	187	1,384	a 139	105	92	6	
4	239	231	1,954	774	a 756	86	2,087	219	108	4	3	
5	a 180	236	1,429	572	693	1,032	1,562	264	115	a 38	5	
6	211	236	1,200	a 532	549	579	a1,143	330	117	69	3	
7	166	236	791	583	522	437	869	436	a 108	5	6	
8	166	236	638	561	418	a 376	695	246	187	71	5	
9	171	a 175	a 482	682	362	381	435	337	151	69	a 5	
10	159	211	483	2,363	296	341	813	a 264	355	47	4	
11	159	196	467	1,689	a 264	621	538	319	297	40	3	
12	a 100	181	1,101	1,329	281	524	402	241	154	a 29	5	
13	121	156	1,633	a1,281	192	458	a 232	160	132	42	6	
14	129	81	1,798	1,109	192	669	205	127	a 100	54	6	
15	136	81	1,645	736	171	a 738	245	121	135	46	6	
16	136	a 40	a1,886	620	139	581	394	107	293	420	a 65	
17	136	81	4,307	622	133	430	302	a 64	251	417	5	
18	133	81	2,796	620	a 110	349	231	166	201	411	5	
19	a 95	81	1,574	589	221	298	196	160	201	a1,971	3	
20	136	81	1,200	a 539	327	305	a 994	219	221	1,732	3	
21	159	81	1,046	539	249	857	1,349	209	a 10	1,203	3	
22	216	81	1,167	542	192	a 956	2,131	193	101	856	5	
23	451	a 40	a1,236	434	135	619	1,381	160	165	730	a 9	
24	526	81	1,429	422	460	363	769	(a)	218	681	4	
25	781	81	1,489	331	a 954	297	1,029	67	172	780	3	
26	a 530	81	1,200	332	708	1,219	709	67	662	a 628	4	
27	486	511	1,079	a 290	499	1,143	a 617	67	507	648	5	
28	481	736	1,046	342	340	827	1,029	64	a 418	805	6	
29	456	.....	2,631	344	327	a 739	714	64	973	3,52	5	
30	331	.....	a3,855	1,510	410	801	508	163	853	2,894	a 6	
31	231	.....	3,276	.....	435	.....	383	(a)	.....	1,656	.....	
Mean	257	178	1,689	813	101	565	804	194	246	864	56	

a Sunday.

Estimated monthly discharge of East Canada Creek at Dolgeville, N. Y.

[Drainage area, 256 square miles.]

Month.	Mean discharge.	Run-off.	
		Second-feet per square mile.	Depth in inches.
1902.	*Sec.-ft.*		
January	257	1.00	1.15
February	178	.69	.72
March	1,689	6.59	7.35
April	813	3.17	3.65
May	101	.39	.45
June	565	2.59	2.99
July	804	3.14	3.50
August	194	.76	.84
September	246	.96	1.07
October	864	3.36	3.87
November	585	2.28	2.54
December	1,049	4.10	4.71
The year	612	2.42	32.84

EAST CANADA CREEK NEAR EASTCREEK, N. Y.

A series of current-meter measurements from boat and cable were made at a point about 2 miles above Eastcreek, N. Y., October 20 to November 6, 1900. The discharge measurements were made by Joseph Kemper, civil engineer, for the city of Little Falls. A current-meter measurement of the discharge was made each day during the continuation of the gage readings. The accompanying table shows the results of current-meter measurements and the corresponding daily gage readings. The velocity was measured at intervals of 5 feet across the stream by the six-tenths depth method. Meter No. 89 of the United States Geological Survey was used. The object of the measurements was to determine the effect of diversion from Spruce Creek and Beaver Brook, two tributaries of East Canada Creek entering above Dolgeville, and serving as sources of public water supply for Little Falls. Contemporaneous measurements of Spruce Creek, the results of which are given elsewhere, were also made. During the continuation of the measurements no water was drawn from Spruce Creek; the entire supply was taken from Beaver Brook, and there was no inflow from East Canada Creek to Beaver Brook, with the exception of the period from October 30 to November 2, inclusive. During this period the total flow of Beaver Brook, together with that

from Spruce Creek, entered East Canada Creek. The drainage area above the point of measurement is 280 square miles.

Measured discharge of East Canada Creek near Eastcreek, N. Y.

Date.	Gage height.	Discharge.	Run-off.
1901.	*Feet.*	*Second-feet.*	*Second-feet per square mile*
October 20	1.41	301.33	1.07
October 21	1.40	289.92	1.04
October 22	1.28	238.66	.85
October 23	1.29	228.55	.82
October 24	1.40	313.43	1.12
October 25	1.20	220.76	.79
October 26	1.19	201.47	.72
October 27	1.17	175.69	.63
October 28	1.04	182.64	.65
October 29	1.15	176.24	.63
October 30	1.17	[a]214.78	.77
October 31	1.25	[a]228.76	.82
November 1	1.19	[a]221.50	.79
November 2	1.22	[a]218.60	.78
November 3	1.11	177.48	.63
November 4	1.12	172.84	.62
November 5	1.14	173.76	.62
November 6	1.18	188.56	.67

[a] Including Beaver Brook.

MOHAWK RIVER AT LITTLE FALLS, N. Y.

This gaging station was established September 23, 1898, and is described in Water-Supply Paper No. 65, pages 162 to 165, where the monthly mean run-off for preceding years may be found. The gaging station is situated at the dam and mills of the Gilbert Knitting Company and the Little Falls Paper Company, where records of the depth wasted over the dam and of the run of the water wheels are kept.

The spring freshet of March 1 and 2, 1902, caused a discharge of Mohawk River at Little Falls estimated at 27,000 second-feet, or 2[illegible] second-feet per square mile.

Mean daily flow, in second-feet, of Mohawk River at Little Falls, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
.....	1,332	1,519	18,024	6,791	6,306	a3,163	4,725	1,777	1,084	2,587	4,122	2,399
.....	1,373	a1,107	a27,505	5,334	4,506	2,297	4,389	3,863	1,069	1,806	a2,329	1,178
.....	1,410	1,163	22,173	5,099	3,752	2,141	5,821	a2,641	1,110	1,487	2,414	2,698
.....	1,296	889	15,793	4,268	a3,650	2,176	1,232	1,875	1,110	1,447	2,297	3,486
.....	a1,108	1,069	10,117	3,610	3,201	4,646	9,320	1,631	1,026	a1,563	2,141	5,952
.....	1,366	1,119	7,680	a3,287	3,139	3,141	a8,486	2,077	956	1,760	2,028	2,299
.....	1,369	1,119	5,951	3,310	3,528	2,162	6,800	5,001	a1,454	2,255	1,737	a1,957
.....	1,369	924	4,969	3,008	2,584	a2,288	6,040	4,931	1,568	3,205	2,599	1,839
.....	1,326	a939	a4,087	3,318	1,968	3,305	5,262	4,920	1,649	2,997	a1,856	1,646
.....	1,286	956	3,850	7,759	1,710	2,456	5,088	a3,408	2,761	2,247	1,957	1,536
.....	1,256	956	3,847	7,135	a1,660	4,351	4,272	2,478	2,466	2,113	1,737	1,762
.....	a963	1,069	8,669	5,145	1,223	4,263	3,548	3,644	1,601	a1,623	2,245	1,813
.....	1,115	1,069	14,508	a3,870	1,340	4,057	a2,082	3,179	1,348	1,613	3,310	1,616
.....	1,115	1,069	14,866	4,002	1,383	3,273	1,878	2,230	a1,141	1,613	3,577	a1,635
.....	1,155	1,018	11,881	3,256	1,210	a3,152	2,012	1,779	1,435	1,567	2,715	1,877
.....	1,160	a770	a14,465	3,008	1,167	4,473	5,718	1,510	1,250	1,472	a2,261	2,004
.....	1,120	956	13,886	2,287	1,215	3,426	4,498	a1,642	1,290	1,305	1,998	5,565
.....	1,098	699	15,440	2,692	a857	3,119	2,878	1,065	922	1,191	2,519	5,797
.....	a936	976	9,744	1,437	1,608	1,783	2,602	1,778	951	4,628	2,028	5,958
.....	1,551	956	7,177	a1,988	1,603	1,830	a4,740	1,870	954	a5,631	1,930	5,177
.....	952	921	5,176	2,404	1,559	1,649	7,299	1,616	a828	4,070	1,838	a4,817
.....	1,155	893	4,684	2,015	1,112	a3,782	8,699	1,616	798	2,526	1,852	6,665
.....	2,458	a2,404	a5,150	2,128	1,111	2,959	7,306	1,844	943	2,517	a2,214	7,890
.....	2,341	1,069	5,572	2,336	1,691	2,287	6,114	a1,664	812	2,993	2,589	6,082
.....	2,237	1,069	5,255	2,014	a4,322	1,831	4,261	1,480	481	2,316	2,354	5,301
.....	a1,436	1,211	4,632	1,933	4,494	3,291	3,158	1,328	871	2,951	1,892	4,576
.....	1,729	1,689	4,352	a2,733	5,020	6,027	a4,073	1,197	998	a2,558	3,315	3,275
.....	2,133	3,449	4,195	2,773	4,132	4,977	4,701	1,284	a924	10,758	4,650	a2,825
.....	1,971	.....	5,849	2,355	3,309	a3,328	3,429	1,018	3,249	11,311	3,748	2,574
.....	1,786	.....	a9,329	4,093	3,718	3,503	2,462	986	3,511	8,373	a2,476	2,295
.....	1,637	.....	9,336	.....	4,812	.....	2,086	(a)	.....	7,235	.....	2,464
Mean ...	1,433.2	1,173.1	9,457.5	3,512.6	2,640.5	3,170.9	4,964.2	2,244.9	1,351.9	3,283.8	2,508	3,448

a Sunday.

Estimated monthly discharge of Mohawk River at Little Falls, N. Y.

[Drainage area, 1,306 square miles.]

Month.	Mean discharge.	Run-off.	
		Second-feet per square mile.	Depth in inches.
1902.	*Sec. feet.*		
January	1,433	1.10	1.27
February	1,173	.90	.94
March	9,457	7.25	8.36
April	3,513	2.69	3.00
May	2,641	2.02	2.33
June	3,171	2.43	2.71
July	4,984	3.82	4.40
August	2,200	1.68	1.94
September	1,352	1.03	1.15
October	3,284	2.51	2.89
November	2,508	1.94	2.17
December	3,448	2.64	3.04
The year	3,264	2.50	34.77

SCHOHARIE CREEK AT MILLPOINT, N. Y.

The record at this station, which is maintained to replace temporarily the record at Schoharie Falls dam on the same stream, has been continued throughout the present year. No discharge measurements were made during 1902. A description of this station and the results of records kept on Schoharie Creek at Fort Hunter and Schoharie Falls may be found in Water-Supply Paper No. 65, pages 167 to 172.

Daily gage height, in feet, of Schoharie Creek at Millpoint, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	2.90	1.45	9.65	4.00	2.55	1.25	2.00	2.30	0.85	4.15	2.45	1.55
	2.50	1.45	7.60	3.70	2.35	1.15	2.00	3.20	.80	3.50	2.20	1.50
	1.85	1.45	6.70	3.50	2.15	1.10	1.95	2.90	.75	2.75	2.15	1.45
	1.70	1.45	4.80	2.90	1.90	1.50	1.95	2.45	.70	2.70	2.10	1.60
	1.60	1.40	4.20	2.50	2.00	1.45	2.00	2.05	.65	2.70	2.00	1.65
	1.60	1.40	3.60	2.10	1.85	1.35	2.05	1.70	.65	2.35	1.90	1.75
	1.55	1.35	2.85	2.05	1.70	1.25	2.05	1.60	.60	2.20	1.80	1.80
	1.50	1.35	2.25	2.05	1.65	1.25	2.10	1.40	.60	2.05	1.75	1.90
	1.50	1.35	2.15	2.25	1.60	1.20	2.00	1.20	.60	1.95	1.60	2.30
	1.50	1.40	3.10	2.20	1.70	1.20	1.85	1.40	.55	1.70	1.55	3.00
	1.45	1.50	3.70	2.20	1.65	1.15	1.65	1.50	1.60	1.65	1.55	3.10
	1.45	1.75	5.55	3.30	1.40	1.30	1.55	1.50	1.55	1.80	1.50	3.05
	1.45	1.50	6.87	3.60	1.40	1.25	1.40	1.45	1.55	2.50	1.50	2.95
	1.45	1.50	5.20	3.50	1.35	1.25	1.25	1.35	1.50	2.25	1.45	2.90
	1.40	1.50	4.20	3.00	1.35	1.20	1.15	1.25	1.45	2.10	1.40	2.90
	1.35	1.45	3.65	3.00	1.30	1.20	1.10	1.15	1.35	1.90	1.40	2.95
	1.35	1.45	4.30	2.80	1.25	1.20	1.05	1.10	1.30	1.75	1.35	4.00
	1.70	1.40	4.75	2.50	1.20	1.15	1.00	1.05	1.50	1.70	1.30	3.60
	1.50	1.40	3.75	2.30	1.20	1.15	.95	1.00	1.35	1.70	1.30	3.50
	1.50	1.40	2.40	2.05	1.15	1.10	1.07	1.35	1.60	1.65	1.30	3.45
	1.35	1.45	2.20	2.00	1.10	1.20	6.47	1.50	1.60	1.60	1.30	3.40
	1.50	1.50	2.30	1.95	1.05	1.20	5.10	1.30	1.35	1.55	1.25	0.65
	4.30	1.50	2.15	1.95	1.00	1.25	4.50	1.15	1.20	1.50	1.25	0.00
	3.15	1.50	2.05	1.90	.95	1.25	4.20	1.05	1.15	1.45	1.25	3.10
	2.30	1.50	2.20	1.90	.95	1.20	4.10	1.00	1.10	1.40	1.25	2.75
	2.15	1.55	3.15	1.85	.95	1.20	3.10	.90	1.20	1.35	1.20	2.50
	2.20	1.55	3.25	1.80	1.00	1.15	2.80	.80	1.80	1.30	1.20	2.40
	2.00	1.60	3.50	1.80	1.10	1.10	2.60	.75	4.02	4.12	1.70	2.35
	1.85	.....	3.80	1.75	1.20	1.10	2.50	.90	5.65	4.20	1.65	2.15
	1.75	.....	4.00	2.10	1.35	1.10	2.30	.90	4.80	2.90	1.55	2.10
	1.60	.....	4.10	.....	1.30	.....	2.30	.85	.....	2.70	.....	2.15

SCHOHARIE CREEK AT PRATTSVILLE, GREENE COUNTY, N. Y.

Schoharie Creek above Prattsville drains a rugged mountainous area almost entirely wooded. The drainage basin, embracing an area 243 square miles, lies wholly within Greene County. The basin is surrounded by continuous mountain ranges, and intervening ridges livide the main stream from its principal tributaries, Batavia Kill, East Kill, and West Kill.

A gaging station was established at the highway bridge in Prattsville village November 7, 1902, by C. C. Covert; the gage datum is referred to the United States Geological Survey bench mark, a circle marked on a bowlder on right-hand end of bridge on the downstream side; elevation 1,151 feet. A 15-foot weight and wire gage, having a boxed horizontal scale, is attached to the steel floor beams of the bridge on the upstream side. The elevation of the water surface

when the gage reads zero is 1,130.03. The bridge has a single span of 185 feet. Measurements are made on the downstream side. Bridge is divided into 10-foot intervals, beginning at top of left-hand abutment.

The river stage is observed at 7 to 8 a. m. and 4 to 5 p. m. each day by James Brennam. A current-meter measurement by C. C. Covert November 7, 1902, showed a flow of 342 second-feet, the gage height being 5.565. A measurement by F. H. Tillinghast December 4, 1902, gage height 5.60, showed a discharge of 345 second-feet.

Mean daily gage height, in feet, of Schoharie Creek at Prattsville, N. Y.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1902.			1902.			1902.		
1		5.20	12	5.40	5.30	23	5.10	[illegible]
2		5.20	13	5.35	5.20	24	[illegible]	[illegible]
3		5.50	14	5.30	5.20	25	5.35	[illegible]
4		5.60	15	5.30	5.20	26	5.15	[illegible]
5		5.53	16	5.30	5.20	27	5.40	[illegible]
6		5.50	17	5.30	7.55	28	5.35	[illegible]
7		5.50	18	5.30	7.20	29	5.30	[illegible]
8		5.50	19	5.20	6.18	30	5.30	[illegible]
9	5.40	5.45	20	5.20	6.00	31		[illegible]
10	5.40	5.40	21	5.20	5.95			
11	5.40	5.35	22	5.20	9.30			

MOHAWK RIVER AT DUNSBACH FERRY, N. Y.

This station is located at the dam of the West Troy Water Company, 9 miles from the mouth of Mohawk River. The station was established March 12, 1898, and a record has been maintained since that date with the exception of the period April, 1899, to August, 1900.

Records were formerly maintained on Mohawk River at the New York State dam at Rexford Flats and at Freeman's bridge, Schenectady, about 4 and 8 miles above Dunsbach Ferry, respectively. Owing to the practical duplication of these records at Dunsbach Ferry gaging station, the Rexford Flats and Freeman's bridge stations were discontinued January 1, 1902. Description of the gaging station at Dunsbach Ferry, as well as the others mentioned, may be found in Water-Supply Paper No. 65, pages 172 to 183, where the results of gagings are also given.

The left wing of the Dunsbach Ferry dam was injured during high water of 1902, necessitating a slight change in the discharge calculation. Owing to roughness of the injured portion of the crest, the data are considered somewhat less precise than formerly. Repairs are in progress. During the year 1902 a 66-inch old pattern American turbine in the adjoining pumping station has been replaced by a 72-inch Victor turbine. A record of the effective head of the water wheel

l of the extent to which the wheels are run is kept, from which the charge through the turbines is calculated and added to the flow r the dam to obtain the total flow of the stream.

Mean daily flow, in second-feet, of Mohawk River at Dunsbach Ferry, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	5,120	3,320	(a)	15,700	5,840	2,950	5,450	3,825	1,250	12,050	9,950	6,300
	3,151	3,151	(a)	12,325	9,100	2,650	6,500	4,125	1,250	8,400	6,975	5,870
	3,151	2,644	.....	9,600	8,475	2,350	7,850	3,825	1,200	6,500	5,675	5,870
	3,320	2,644	45,550	8,375	6,750	3,500	8,375	4,125	1,250	4,850	4,700	7,670
	2,982	2,544	25,150	6,500	6,925	3,500	9,100	3,225	1,200	4,300	4,525	12,100
	2,813	2,206	17,550	5,650	6,925	2,925	9,100	2,500	1,200	3,675	4,025	10,200
	2,644	2,106	12,350	5,200	4,850	2,925	12,750	3,825	1,200	3,300	3,875	7,200
	2,475	2,106	7,150	4,470	4,470	2,350	9,900	5,840	1,225	3,400	3,725	5,100
	2,644	2,037	6,250	8,100	3,950	3,050	7,150	5,225	1,275	3,250	3,725	3,880
	2,644	1,768	6,250	16,425	3,350	2,925	5,225	4,470	1,545	3,725	3,575	3,100
	2,306	1,599	6,700	23,200	3,050	3,225	4,470	3,975	2,350	3,550	3,070	3,730
	2,475	1,868	9,900	20,300	2,925	4,300	3,975	4,125	2,950	3,550	3,070	4,120
	2,475	1,699	34,000	13,800	2,650	5,450	3,500	3,025	2,950	4,025	4,025	4,300
	2,137	1,530	34,000	9,625	2,100	4,650	2,925	2,800	2,650	3,900	5,475	4,530
	1,968	1,429	23,450	7,625	2,100	5,025	3,050	1,825	2,500	3,550	6,300	4,900
	1,799	1,630	20,700	5,225	1,950	6,050	2,925	1,545	2,250	3,400	5,100	5,280
	1,799	1,429	28,450	5,040	1,675	6,500	2,650	1,475	1,950	3,250	4,175	9,150
	1,429	1,429	32,350	4,470	1,545	4,850	2,925	1,350	1,545	2,950	4,025	19,700
	1,630	1,429	23,200	3,825	1,475	4,125	2,925	1,400	1,400	4,520	4,025	16,710
	1,429	1,429	14,105	3,200	1,400	3,200	6,500	1,450	1,325	8,930	4,175	14,530
	1,630	1,429	10,400	3,200	1,545	1,725	15,700	1,475	1,250	1,495	3,725	12,950
	2,186	1,429	9,350	2,780	2,350	2,225	21,775	1,950	1,200	9,950	3,725	16,450
	6,022	(a)	11,050	2,650	1,675	1,825	19,200	1,825	1,200	5,275	3,400	29,350
	7,923	.....	12,650	2,780	1,825	1,825	14,700	1,675	1,200	4,900	3,250	22,950
	6,022	.....	11,500	3,675	2,800	3,050	14,125	1,475	1,200	5,700	3,100	11,200
	3,720	.....	10,150	3,050	3,825	2,800	9,100	1,400	1,200	5,275	4,010	7,150
	4,520	.....	9,100	3,050	5,450	3,350	7,850	1,350	1,350	6,000	4,900	7,150
	4,520	.....	7,850	3,050	7,150	4,850	6,925	1,350	2,650	15,750	7,200	5,100
	4,720	.....	9,650	3,825	5,250	4,350	6,500	1,300	8,475	28,150	8,650	3,750
	4,320	.....	17,100	4,125	4,300	4,125	4,850	1,300	17,400	18,200	7,000	4,730
	3,920	.....	19,650	.....	3,400	.....	3,825	1,300	.....	14,775	.....	5,100

a No record from February 23 to March 3.

Estimated monthly discharge of Mohawk River at West Troy Company's dam at Dunsbach Ferry, N. Y.

[Drainage area, 3,440 square miles.]

Month.	Mean discharge.	Run-off. Second-feet per square mile.	Depth in inches.
1902.	*Sec.-feet.*		
January	3,253	.95	
February 1 to 22	[a] 1,948	[a] .57	
March 4 to 31	[a] 16,986	[a] 4.94	
April	7,361	2.14	
May	3,906	1.14	
June	3,554	1.03	
July	4,251	1.24	
August	2,592	.75	
September	2,386	.69	
October	6,466	1.88	
November	4,771	1.39	
December	9,036	2.63	
The year	5,542	1.61	

[a] Partial month. Record for days of high flood not obtainable. Due to break in dam.

UPPER HUDSON DRAINAGE BASIN.

INDIAN RIVER AT INDIAN LAKE DAM, HAMILTON COUNTY, N. Y.

This record includes the stage of water in and amount of discharge from Indian Lake storage reservoir. The reservoir was built for the purpose of ameliorating the water-power deficiency to mills on Hudson River during low water. The dam is of masonry and forms a lake having a surface area of 7.87 square miles or 5.54 per cent of the drainage area of 142 square miles.

Stage of water in Indian Lake reservoir at Indian Lake, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
.....	20.08	18.79	15.00	29.92	36.17	35.54	36.25	34.88	31.92	28.92	29.08	25.58
.....	20.17	18.75	15.42	30.83	36.17	35.54	36.29	34.79	31.75	28.75	28.83	25.67
.....	20.21	18.71	16.17	30.58	36.17	35.58	36.33	34.75	31.58	28.58	28.58	25.79
.....	20.21	18.67	16.67	30.83	36.13	35.58	36.46	34.67	31.38	28.42	28.33	25.92
.....	20.25	18.63	17.08	31.08	36.08	35.58	36.42	34.58	31.17	28.33	28.08	26.00
.....	20.29	18.58	17.42	31.25	36.00	35.58	36.29	34.67	31.00	28.50	27.92	26.00
.....	20.33	18.54	17.75	31.42	35.79	35.63	36.13	34.75	30.83	28.17	27.75	25.83
.....	20.33	18.50	18.00	31.58	35.63	35.67	36.00	34.83	30.71	28.17	27.67	25.67
.....	20.37	18.46	18.17	32.08	35.50	35.67	35.88	34.83	30.75	28.21	27.75	25.50
.....	20.42	18.42	18.33	33.00	35.42	35.67	35.79	34.75	30.58	28.25	27.83	25.33
.....	20.42	18.37	18.50	33.50	35.33	35.67	35.63	34.75	30.79	28.33	27.92	25.17
.....	20.38	18.33	18.83	33.75	35.17	35.67	35.50	34.67	30.54	28.37	28.00	25.08
.....	20.25	18.29	19.17	34.00	35.00	35.67	35.42	34.58	30.29	28.42	28.17	25.00
.....	20.12	18.25	19.75	34.25	34.92	35.71	35.42	34.54	30.33	28.50	28.37	25.08
.....	20.08	18.17	20.25	34.42	34.83	35.75	35.50	34.46	30.33	28.50	28.21	25.17
.....	19.00	17.92	20.67	34.58	34.75	35.75	35.67	34.38	30.33	28.46	28.04	25.33
.....	19.92	17.58	21.83	34.71	34.63	35.75	35.63	34.33	30.38	28.42	27.83	25.50
.....	19.79	17.21	22.92	34.83	34.50	35.75	35.54	34.25	30.42	28.42	27.67	25.67
.....	19.67	16.92	23.58	35.00	34.42	35.79	35.50	34.17	30.46	28.42	27.50	25.83
.....	19.58	16.67	24.00	35.00	34.38	35.79	35.58	34.00	30.50	28.42	27.33	25.83
.....	19.50	16.42	24.33	34.96	34.33	35.83	35.75	33.83	30.54	28.42	27.17	25.83
.....	19.50	16.25	24.58	34.92	34.25	35.83	35.92	33.71	30.54	28.46	27.00	25.92
.....	19.50	16.00	24.83	34.92	34.33	35.83	35.92	33.58	30.42	28.50	26.83	26.00
.....	19.42	15.75	25.17	34.96	34.54	35.88	35.75	33.42	30.17	28.58	26.67	26.00
.....	19.33	15.50	25.42	35.00	34.67	35.92	35.58	33.21	29.88	28.75	26.50	26.00
.....	19.25	15.25	25.67	35.25	34.92	35.96	35.42	33.00	29.67	28.92	26.33	25.92
.....	19.17	15.00	26.00	35.42	35.08	36.08	35.38	32.83	29.50	29.08	26.17	25.75
.....	19.08	14.83	26.50	35.50	35.25	36.17	35.25	32.67	29.33	29.30	26.00	25.63
.....	19.00	.....	17.33	35.50	35.33	36.17	35.17	32.50	29.17	29.42	25.83	25.42
.....	18.92	.....	28.50	36.00	35.38	36.17	35.08	32.25	29.04	29.42	25.67	25.29
.....	18.83	.....	29.25	.....	35.50	.....	34.96	32.08	.....	29.37	.....	25.17

SCHROON RIVER NEAR WARRENSBURG, N. Y.

The record at this station, which is situated at the dam and mill of ıe Schroon River Pulp Company near the mouth of Schroon River, tributary of Upper Hudson River, was established November, 1895. ı record of the run-off for preceding years together with a description f the drainage area may be found in Water-Supply Paper No. 65, pages 5 to 47. The high water of March 21, 1902, resulted in a discharge f 7,042 second-feet at this dam or 12.51 second-feet per square mile rom the tributary drainage area of 563 square miles. The record has ıeen maintained in cooperation with the officials of the Schroon River ³ulp Company. The record for the first three months of 1902 is given ıerewith. Owing to change in management of company, the data for he remaining months of the year are not available at present.

Mean daily flow, in second-feet, of Schroon River below Warrensbury, N. Y.

Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.
1902.				1902.				1902.			
1	761	612	740	12	(a)	535	4,462	23	612		
2	761	(a)	(a)	13	574	535	4,652	24	612		
3	761	574	2,957	14	574	535	5,087	25	612		
4	761	574	3,052	15	574	535	5,397	26			
5	(a)	574	3,287	16	574	(a)	(a)	27	612	535	
6	761	574	3,392	17	574	574	5,497	28	612	535	
7	761	574	3,482	18	574	477	5,647	29	612		
8	806	574	3,287	19	(a)	477	5,647	30	612		
9	806	(a)	(a)	20	612	477	5,497	31	612		
10	806	574	2,582	21	612	477	7,042				
11	768	595	2,377	22	612	477	4,342				

a Sunday.

Estimated monthly discharge of Schroon River below Warrensbury, N. Y.

[Drainage area, 563 square miles.]

Month.	Mean discharge.	Run-off	
		Second-feet per square mile.	Depth in inches
1902.	*Sec.-feet.*		
January	664	1.18	
February	532	0.95	
March	3,850	6.85	

HUDSON RIVER AT FORT EDWARD, N. Y.

This station was established by George W. Rafter in connection with the Upper Hudson storage surveys in 1895. The record preceding the year 1899 has not been published. The station is described and the results as to run-off are given in Water-Supply Paper No. pages 48 to 50.

Mean daily flow, in second-feet, of Hudson River at Fort Edward, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	2,751	1,366	2,491	14,307	7,600	a 4,865	5,192	5,288	2,231	4,763	8,894	3,888
	2,166	a 2,237	a 8,140	12,870	10,259	6,738	5,192	5,197	2,715	5,031	a 10,460	3,475
	2,478	2,963	17,818	9,155	4,817	4,626	14,597	a 7,255	2,449	2,624	9,317	3,491
	1,128	2,193	20,450	8,479	a 7,255	4,626	15,310	8,254	2,276	2,085	7,335	4,357
	a 2,231	2,193	19,985	4,498	9,661	5,192	15,244	6,081	2,105	a 2,530	6,315	4,420
	2,647	2,219	15,099	a 4,135	7,176	5,192	a 10,460	5,134	1,104	4,053	5,611	1,898
	2,247	2,593	15,241	5,213	8,829	2,776	10,149	7,286	a 3,155	4,219	5,396	a 2,834
	2,647	1,248	13,110	4,902	6,351	a 4,135	7,926	7,286	3,823	4,312	2,804	3,619
	2,942	a 2,231	a 13,670	4,642	6,022	6,684	6,081	5,256	3,200	4,312	a 4,865	3,483
	2,674	2,447	8,169	10,335	2,776	4,626	5,821	a 7,255	2,924	4,053	5,035	3,211
	1,144	2,447	7,821	15,170	a 4,135	4,626	5,821	8,272	3,481	1,546	3,900	3,634
	a 2,231	2,193	8,000	11,997	4,829	5,196	2,916	5,992	3,220	a 1,950	3,740	3,718
	2,767	2,193	7,976	a 12,030	4,568	1,578	a 4,135	6,042	1,896	3,225	4,025	1,558
	2,507	2,193	15,178	10,487	4,569	4,135	4,594	5,461	a 2,814	2,835	4,310	a 3,474
	2,247	1,155	15,754	7,625	4,254	a 6,235	2,949	5,096	3,504	3,135	2,804	2,329
	2,647	a 1,950	a 15,310	7,086	4,281	6,685	4,743	2,906	2,452	3,628	a 6,035	2,827
	2,507	2,162	29,707	6,240	1,958	4,886	5,192	a 4,135	2,107	4,053	7,287	4,401
	1,144	2,334	25,031	5,554	a 115	5,031	4,886	3,968	1,723	1,899	5,396	6,632
	a 1,950	2,221	21,577	2,822	3,894	5,192	2,389	3,876	1,963	a 4,135	5,031	5,590
	2,108	2,478	18,306	a 4,135	5,821	6,683	a 5,645	3,791	897	6,684	5,192	3,217
	1,966	2,479	12,977	6,931	4,025	5,198	7,556	3,791	a 1,680	5,611	5,396	a 5,654
	1,765	1,278	10,483	5,135	3,483	a 6,235	7,235	3,791	1,699	5,396	3,277	8,268
	2,369	a 1,950	a 13,130	4,028	3,482	8,742	9,368	1,718	1,547	4,886	a 4,135	10,037
	3,145	2,479	10,421	4,028	1,728	5,399	9,712	a 2,231	1,459	4,363	4,364	10,037
	1,740	2,339	10,539	3,769	a 30	4,886	9,266	4,676	1,579	4,159	4,364	7,690
	a 3,155	2,447	8,431	1,992	4,421	4,686	6,147	3,506	2,047	a 4,135	4,310	9,550
	3,785	2,858	9,155	a 5,645	4,420	5,192	a 6,835	3,248	872	4,421	4,310	6,126
	3,380	3,262	7,823	6,576	4,421	2,850	7,658	2,963	a 3,474	4,369	4,310	a 6,835
	2,969	.....	5,386	6,575	3,822	a 7,255	7,556	3,802	4,857	10,588	1,982	6,632
	2,711	.....	a 11,500	5,439	4,440	8,639	6,931	1,294	4,712	14,074	a 5,654	5,590
	2,969	.....	14,127	.....	2,005	.....	5,830	a 2,231	.....	15,014	.....	5,348

a Sundays.

Estimated monthly discharge of Hudson River at Hudson Paper Mill Company's mill at Fort Edward, N. Y.

[Drainage area, 2,800 square miles.]

Month.	Mean discharge.	Run-off	
		Second-feet per square mile.	Depth in inches.
1902.	*Sec.-feet.*		
January	2,422	0.86	0.99
February	2,218	.79	.82
March	13,316	4.75	5.47
April	7,060	2.52	2.81
May	4,692	1.67	1.93
June	5,293	1.53	1.71
July	7,204	2.57	2.96
August	4,743	1.69	1.95
September	2,466	.88	.98
October	4,841	1.73	1.99
November	5,191	1.87	2.09
December	4,961	1.76	2.03
The year	5,367	1.88	25.73

HUDSON RIVER AT MECHANICVILLE, N. Y.

This gaging record, which has been maintained since 1888 by the Duncan Company at their dam and paper mill, is furnished by R. P. Bloss, C. E., engineer of the company. The station is described in Water-Supply Paper No. 65, pages 50 to 53, and the run-off data for the years 1898 to 1901 are given. The run-off for earlier years may be found in the annual reports of the United States Geological Survey on Progress of Stream Measurements.

Mean daily flow, in second-feet, of Hudson River at Mechanicville, N. Y.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.											
	5,019	37,064	28,287	18,099	6,444	6,524	6,812	2,621	6,823	a14,276	a6,180
	5,050	27,300	24,412	18,886	7,611	6,524	8,193	4,245	6,233	a11,253	a4,928
	5,697	41,362	20,724	15,881	6,174	6,976	7,986	a3,201	6,547	a12,350	a4,849
	4,160	32,881	17,576	14,365	6,883	10 275	9,530	a2,972	5,504	a10,094	a4,995
	3,754	29,491	14,989	16,173	6,635	14,487	8,555	a3,071	4,431	a8,822	a6,241
	3,625	21,893	.....	14,315	6,810	12,225	6,933	a3,178	6,319	a8,044	a5,775
	3,658	21,145	12,778	14,820	6,361	11,698	8,393	a1,789	5,029	a7,592	a3,331
	3,358	19,256	10,843	11,988	5,050	9,523	9,168	a5,021	5,637	a7,302	a5,524
	3,925	15,848	11,848	11,192	7,398	8,335	9,289	a4,216	5,795	a6,087	a5,007
	4,313	16,575	22,112	10,843	5,985	8,148	8,174	a4,181	5,477	a7,328	a4,186
	2,509	14,541	26,913	9,360	6,436	7,748	9,593	a4,441	5,020	a5,688	a5,411
	3,889	17,686	25,250	8,923	6,086	6,607	8,955	a4,718	3,471	a5,279	a5,548
	4,034	23,312	24,323	7,645	5,836	4,775	8 630	a4,718	6,033	a5,229	a5,105
	3,964	26,187	21,012	7,848	5,437	6,111	7,628	a3,735	4,557	a5,442	a6,725
	3,818	25,211	16,448	7,070	4,009	4,940	8,140	a5,613	4,502	a6,644	a6,896
	3,944	.....	13,603	6,210	6,529	5,755	6,118	a3,944	4,812	a6,726	a5,507
	5,353	33,274	13,060	6,463	7,173	6,242	4,569	a3,348	4,871	a8,536	a15,846
	4,103	42,940	11,755	5,756	6,798	6,567	5,842	a3,025	4,855	a7,085	a13,714
	4,778	37,036	10,743	4,102	6,798	5,407	4,837	a2,737	3,831	a6,720	a11,962
	5,038	30,551	8,895	5,662	6,086	5,375	4,489	a2,712	7,669	a6,273	a10,219
	5,126	26,048	11,539	6,012	5,812	14,311	4,477	1,707	7,574	a6,961	a8,858
	5,308	24,000	10,071	6,632	5,250	13,391	4,677	4,114	7,174	a6,181	21,649
	5,788	21,696	9,348	4,965	6,848	12,334	4,552	3,134	6,635	a4,504	21,787
	6,212	22,387	9,959	4,620	6,886	11,231	3,350	2,940	5,971	a6,724	16,410
	4,337	19,648	8,446	4,100	6,140	12,346	5,419	2,835	5,457	a5,639	12,697
	4,488	18,311	8,336	7,748	5,600	11,376	4,270	2,597	3,907	a5,206	13,808
	7,353	16,723	9,110	8,760	6,074	9,315	4,109	2,793	6,442	a5,239	12,514
	9,160	16,035	13,298	13,899	6,988	11,501	3,722	2,818	10,658	a5,775	10,172
	.....	19,815	12,098	9,398	5,876	10,049	3,586	6,125	a17,901	a5,410	10,939
	.....	23,220	13,672	9,973	7,461	8,948	3,294	6,741	a17,631	a3,840	8,881
	.....	29,487	.....	10,521	.....	7,936	1,539	.....	a16,951	.....	8,398

a Flashboards irregular; results approximate.

NOTE.—Record not available for January.

Estimated monthly discharge of Hudson River at Mechanicville, N. Y.

[Drainage area, 4,500 square miles.]

Month.	Mean discharge.	Run-off	
		Second-feet per square mile.	Depth in inches.
1902.	*Sec.-feet.*		
February	4,741	1.52	[illegible]
March	25,130	5.53	[illegible]
April	15,222	2.38	[illegible]
May	7,949	1.76	[illegible]
June	6,315	1.40	[illegible]
July	8,934	1.98	[illegible]
August	6,286	1.40	[illegible]
September	3,643	.81	[illegible]
October	6,894	1.53	[illegible]
November	7,076	1.41	[illegible]
December	9,162	1.83	[illegible]

QUACKENKILL CREEK AT QUACKENKILL VILLAGE, N. Y.

The headwaters of Quackenkill Creek lie in a series of storage ponds in central Rensselaer County. These ponds, four in number, have a combined water-surface area of 0.15 square mile. They are situated at an average elevation of 1,485 feet above tide. Quackenkill is tributary to Poestenkill, and the ponds are utilized by mills at Troy to equalize the extremes of flow and increase the low-water discharge of the latter stream. The drainage area of the Quackenkill is for the most part cleared and precipitous.

A gaging record was maintained on the Quackenkill, below the lower highway bridge in Quackenkill village, during 1894. A weir having a crest 8 feet in length was erected across the stream, and observations of the depth on the weir at a stake a short distance upstream were taken daily. The discharge was calculated by the Francis formula. The drainage area above the point of gaging is 18.5 square miles, and above the junction of the stream with the Poestenkill is 30.5 square miles.

The record has been furnished by William G. Raymond, consulting engineer of department of water supply of Troy.

Mean daily flow, in second-feet, of Quackenkill Creek at Quackenkill village, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1894.												
	23.9	13.8	8.9	29.4	15.7	31.8	1.2	8.7	10.2	1.3	34.3	14.6
	27.7	14.6	14.7	27.2	14.4	50.1	.9	8.7	8.6	1.3	36.0	11.7
	31.6	13.3	23.9	17.4	14.3	41.1	.5	10.8	8.5	1.3	68.9	9.2
	36.2	11.9	31.7	32.3	12.5	25.0	2.1	10.6	7.6	2.1	75.8	12.9
	75.2	12.2	55.5	76.6	12.3	23.5	3.2	8.7	6.0	3.6	59.8	11.7
	73.2	10.4	269.6	53.5	9.8	16.2	6.4	8.5	9.6	6.0	94.2	10.9
	51.7	10.6	426.4	40.4	68.8	12.3	13.2	9.3	8.8	6.1	55.1	13.8
	35.2	11.0	189.2	39.0	41.9	11.1	11.7	8.9	8.1	4.8	77.4	9.3
	31.7	11.5	114.4	44.3	26.6	12.2	11.9	8.3	8.3	9.6	56.9	10.2
	22.9	11.8	111.7	42.8	17.4	9.2	9.8	7.0	8.2	34.7	54.3	11.8
	27.8	11.0	145.3	33.5	14.9	8.2	8.3	7.3	8.9	46.7	39.3	13.8
	20.3	11.0	164.8	28.9	13.2	5.3	10.7	7.3	6.5	42.9	29.6	125.9
	18.9	10.2	99.3	26.9	8.7	4.2	8.2	7.8	8.5	28.3	29.4	257.9
	18.5	11.0	83.7	22.6	9.0	4.8	12.1	7.1	7.8	32.0	34.1	141.4
	19.1	10.8	50.6	20.2	6.8	3.6	9.4	7.3	6.3	23.1	31.9	90.4
	47.7	11.5	60.5	19.3	5.2	2.3	11.2	6.9	6.5	17.3	52.1	63.4
	33.4	10.2	33.2	15.7	4.1	2.1	11.1	6.6	6.6	9.7	72.5	93.3
	27.0	12.4	45.1	14.6	4.2	2.1	10.1	7.4	5.1	9.0	51.1	67.7
	30.0	19.6	84.5	12.2	5.5	2.0	10.1	8.7	5.5	11.9	51.8	53.8
	17.4	19.8	65.4	14.0	5.6	5.3	12.0	12.2	10.1	7.0	23.7	34.4
	14.2	17.1	52.9	74.1	4.1	11.1	9.5	13.5	12.2	6.2	25.6	29.8
	14.8	15.1	50.4	109.3	3.9	9.3	12.8	12.6	9.5	7.4	26.8	30.2
	20.7	14.3	173.5	109.7	3.7	5.1	11.9	13.6	3.8	5.5	22.8	15.1
	27.4	13.5	107.8	115.0	3.9	6.0	10.3	13.4	5.3	4.3	34.3	13.4
	57.0	10.7	70.3	72.7	12.8	2.8	5.7	11.0	4.3	5.2	31.9	12.3
	30.7	9.9	58.3	53.2	174.1	1.8	6.0	10.2	3.5	5.3	24.6	11.3
	26.5	9.2	42.8	33.9	12.8	1.8	4.1	10.2	4.0	4.1	24.3	9.9
	20.0	8.7	35.5	26.1	12.9	1.8	9.9	10.2	2.6	4.7	19.4	10.4
	17.6	.....	29.7	25.9	37.0	1.7	9.4	10.2	1.7	5.9	15.2	12.3
	16.8	.....	22.4	21.7	24.3	1.7	9.4	10.2	1.7	3.7	12.8	11.2
	17.0	.....	22.8	.....	21.5	.....	9.5	9.7	.....	4.0	.....	10.2

Estimated monthly discharge of Quackenkill Creek at Quackenkill village, N. Y.

[Drainage area, 18.5 square miles.]

Month.	Mean discharge.	Run-off.	
		Second-feet per square mile.	Depth in inches.
1894.	*Sec.-feet.*		
January	30.0	1.62	1.87
February	12.3	.66	.69
March	88.5	4.56	5.25
April	41.7	2.25	2.51
May	19.7	1.65	1.90
June	10.5	.56	.62
July	8.4	.43	.50
August	9.4	.51	.59
September	6.8	.37	.41
October	11.4	.62	.71
November	42.5	2.29	2.55
December	39.4	2.13	2.45
The year	26.7	1.47	19.85

STREAMS PROPOSED AS SOURCES OF PUBLIC WATER SUPPLY FOR NEW YORK CITY.

In July, 1901, gaging stations were established and a series of discharge measurements undertaken on streams in the Catskill Mountain region and vicinity in cooperation with the department of water supply of New York City. In the following table the drainage area of the several streams are given:

Drainage area of streams proposed as sources of water supply for New York City.

Stream.	Location of gaging station.	Drainage area.		
		Above proposed reservoir.	Above gaging station.	Above mouth.
		Sq. miles.	*Sq. miles.*	*Sq. miles.*
Tenmile River	Dover Plains, N. Y.	200	195	195
Housatonic River	Gaylordsville, Conn.	1,020	1,020	1,020
Catskill Creek	South Cairo, N. Y.	140	260	260
Esopus Creek	Kingston, N. Y.	242	312	312
Wallkill River	Newpaltz, N. Y.	464	735	735
Rondout Creek	Rosendale, N. Y.	184	365	365
Fishkill Creek	Glenham, N. Y.	158	198	198

[a] Above junction with Wallkill River.

A gaging station on Housatonic River at Gaylordsville, Conn., tablished October 23, 1900, by the United States Geological Survey is so included.

ESOPUS CREEK AT KINGSTON, N. Y.

This gaging station is located at the Washington avenue bridge in ingston, and was established July 5, 1901. The drainage basin is escribed and results of discharge measurements and gage readings or 1901 are given in Water-Supply Paper No. 65, pages 63 to 66. he maximum observed gage heights have been as follows:

Gage heights of Esopus Creek at Kingston.

Date.	A. M.	M.	P. M.
1901.			
December 15	20.0		22.75
December 16	17.0		18.4
1902.			
January 22			16.15
March 1	20.45		19.75
March 2	16.1		17.52
March 3	17.25		
March 17	18.3	20.15	18.22
September 29	20.75		24.1
September 30	18.8		15.9
December 17	16.8		

The following table gives a list of the discharge measurements made on Esopus Creek at Kingston, N. Y., during 1902:

Discharge measurements of Esopus Creek at Kingston, N. Y.

Date.	Hydrographer.	Gage height	Discharge
1902.		*Feet.*	*Second-feet.*
June 16	W. W. Schlecht	4.48	1,5[illegible]
September 4	H. K. Barrows	4.49	1[illegible]
August 21	do	4.94	1[illegible]
June 26	W. W. Schlecht	5.02	2[illegible]
June 5	do	5.03	3[illegible]
July 16	H. K. Barrows	5.13	3[illegible]
November 22	F. H. Tillinghast	5.45	3[illegible]
July 9	Barrows and Schlecht	5.81	4[illegible]
May 14	W. W. Schlecht	5.83	4[illegible]
September 23	P. M. Churchill	5.87	4[illegible]
November 11	F. H. Tillinghast	6.00	4[illegible]
August 12	H. K. Barrows	6.28	5[illegible]
May 24	W. W. Schlecht	6.38	6[illegible]
June 5	do	6.41	6[illegible]
November 5	F. H. Tillinghast	6.55	7[illegible]
April 23	W. W. Schlecht	6.94	8[illegible]
May 14	do	7.14	9[illegible]
July 30	H. K. Barrows	7.65	1,1[illegible]
July 24	do	8.11	1,3[illegible]
October 4	P. M. Churchill	9.32	1,8[illegible]
March 12	Horton and Schlecht	9.90	2,[illegible]
April 30	W. W. Schlecht	10.28	2,[illegible]
December 18	F. H. Tillinghast	13.00	3,4[illegible]
April 10	W. W. Schlecht	13.37	5,1[illegible]
December 22	F. H. Tillinghast	16.00	8,3[illegible]
March 1	W. W. Schlecht	20.38	b12,8[illegible]

[a] Measured at Glasgow Bridge, Glenerie.
[b] Large quantities of floating ice in the stream. Surface velocities used

The following measurements were also made during the period of ice obstruction, by W. W. Schlecht:

February 20: Gage height, 5.38; discharge, 245 second-feet; river partly frozen over.

February 15: Gage height, 5.60; discharge, 337 second-feet; river mostly frozen over.

February 7: Gage height, 6.83; discharge, 530 second-feet; river partly frozen.

September 29, 1.30 p. m.: The stream attained a flood stage, giving a reading of 25.25 on the gage.

Mean daily gage height, in feet, of Esopus Creek at Kingston, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	8.20	7.25	20.10	9.35	8.95	4.85	6.38	7.09	4.45	13.38	7.28	5.9
	10.35	7.45	16.82	8.69	8.18	4.83	6.19	7.95	4.48	11.68	6.75	5.7
	9.95	9.35	15.75	8.05	7.78	4.76	6.00	7.10	4.43	10.10	5.83	6.19
	8.40	7.72	11.07	7.64	7.70	4.83	6.40	6.90	4.33	9.50	6.55	6.43
	7.65	7.52	9.45	7.33	7.43	4.70	5.99	6.53	4.38	8 60	6.55	6.33
	7.30	7.16	8.95	7.03	7.11	4.73	6.19	7.08	4.33	9.64	6.25	6.18
	6.95	6.70	7.90	7.18	6.98	4.55	6.16	6.90	4.38	8.68	6.47	6.35
	6.65	6.47	7.68	7.28	6.74	4.63	6.08	3.43	4.38	8.18	6.35	6.6
	6.50	6.14	8.85	13.10	6.55	4.63	5.80	6.18	4.38	7.85	6.13	6.45
	6.40	6.25	9.20	13.86	6.40	4.68	5.58	5.88	7.68	7.40	6.08	6.00
	6.35	5.94	9.05	11.60	6.23	4.58	5.50	5.83	6.00	7.15	7.85	6.35
	5.88	5.88	9.80	10.22	6.10	4.45	5.34	6.25	5.49	9.10	5.95	6.55
	6.00	5.77	11.85	9.41	5.98	4.53	5.15	5.73	5.53	8.47	5.85	6.35
	5.98	5.60	11.82	8.78	5.88	4.58	5.05	5.58	6.18	8.00	5.78	6.4
	5.60	5.58	9.98	8.25	5.70	4.40	4.98	5.38	5.85	7.60	5.73	6.43
	5.58	5.53	9.33	7.90	5.70	4.46	4.99	5.30	5.53	7.33	5.63	6.65
	5.59	5.63	[a]18.28	7.58	5.50	4.78	4.89	5.08	5.30	7.15	5.60	16.20
	5.30	5.89	13.10	7.35	5.33	4.94	4.80	5.10	5.13	6.95	5.60	12.86
	5.50	5.45	10.13	7.10	5.38	4.63	4.78	4.98	5.08	6.75	5.54	11.00
	5.86	5.30	9.20	6.93	5.40	4.60	6.37	4.98	5.30	6.73	5.46	9.95
	4.95	5.35	8.62	6.80	5.28	4.81	10.00	4.88	6.88	6.47	5.45	8.55
	12.73	5.36	8.25	6.78	5.13	5.55	9.50	4.85	6.28	6.30	5.38	15.6
	10.88	5.30	8.20	6.93	5.08	5.13	9.28	4.78	5.88	6.20	5.36	12.80
	8.88	5.36	7.87	6.88	5.00	4.93	8.38	4.65	5.68	6.13	5.36	10.40
	8.00	5.89	7.63	6.58	4.88	4.81	8.58	4.70	5.68	6.30	5.2	9.35
	7.53	6.45	7.43	6.36	5.20	4.93	8.68	4.65	7.00	5.87	5.3	8.7
	8.63	9.30	7.28	6.35	5.20	5.15	8.01	4.55	10.35	5.78	6.0	8.28
	8.08	9.37	7.19	6.20	5.58	4.84	7.75	4.65	9.48	7.83	6.6	8.75
	7.72	.....	11.65	5.98	5.25	4.81	7.19	4.70	[b]22.43	8.35	6.1	9.10
	7.82	.....	12.55	9.81	5.03	7.10	7.68	4.60	17.35	7.75	5.88	8.97
	7.48	.....	10.45	.....	5.03	.....	7.35	4.63	.....	7.50	.....	8.05

[a] Highest water at 1.30 p. m., 18.30.

[b] Highest water at 1.30 p. m., 25.25.

CATSKILL CREEK AT SOUTH CAIRO, N. Y.

This stream is described and the results of current-meter measurements, together with daily gage heights of 1901, are given in Water-Supply Paper No. 65, pages 61 to 63. In relation to the supply available for storage in the proposed reservoirs, the maximum discharge of these streams is of interest. The following table shows a number of the maximum gage readings of 1901, also of 1902. This, in connection

with the accompanying table of discharge measurements, will serve to illustrate the freshet flow of this stream:

Gage heights of Catskill Creek, in feet, at South Cairo, N. Y., during freshets.

Date.	A. M.	P. M.
1901.		
December 15	15.0	[illegible]
1902.		
February 28	.....	[illegible]
March 1	11.5	[illegible]
April 9	11.7	11.6

The following table gives a list of the discharge measurements made on Catskill Creek at South Cairo, N. Y., during 1902:

Discharge measurements of Catskill Creek at South Cairo, N. Y.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
June 13	W. W. Schlecht	2.69	[illegible]
June 24	do	2.70	[illegible]
August 27	H. K. Barrows	2.74	[illegible]
September 5	do	2.79	[illegible]
June 3	W. W. Schlecht	2.82	[illegible]
May 23	do	2.83	[illegible]
September 22	P. M. Churchill	3.32	[illegible]
July 9	H. K. Barrows	3.365	[illegible]
May 10	W. W. Schlecht	3.47	[illegible]
August 13	H. K. Barrows	3.49	[illegible]
November 7	F. H. Tillinghast	3.80	[illegible]
December 3	do	3.90	[illegible]
October 10	P. M. Churchill	3.92	[illegible]
April 22	W. W. Schlecht	4.06	[illegible]
August 2	H. K. Barrows	5.96	[illegible]
December 18	F. H. Tillinghast	5.45	[illegible]
July 23	H. K. Barrows	6.11	[illegible]
April 11	W. W. Schlecht	6.86	[illegible]
March 13	Horton and Schlecht	8.66	[illegible]

A measurement made February 27, 1902, with the stream obstructed by ice, showed the discharge to be 363 second-feet, gage height [illegible]. The stream was frozen from bank to bank, to a depth of 6 to 18 inches.

Mean daily gage height, in feet, of Catskill Creek at South Cairo, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	.....	4.30	11.70	5.35	4.10	2.95	3.48	4.50	2.90	6.18	4.30	3.6
	.....	5.05	9.68	5.88	3.95	2.88	3.28	5.58	2.83	5.63	4.15	3.63
	.....	5.20	6.70	4.95	3.93	2.80	3.13	4.38	2.75	5.20	4.05	3.8
	.....	4.45	6.80	4.88	3.88	2.83	3.10	4.13	2.73	4.80	3.95	4.18
	4.40	4.40	6.35	4.90	3.83	2.88	3.08	3.85	2.73	4.60	3.90	4.0
	4.20	4.40	5.40	4.65	3.78	2.88	4.45	4.45	2.70	4.53	3.83	4.0
	4.05	4.30	4.10	4.40	3.73	2.85	4.20	4.20	2.78	4.40	3.77	3.98
	4.80	4.25	4.10	4.60	3.70	2.90	3.48	3.93	2.78	4.23	3.73	3.8
	3.70	4.20	4.90	11.65	3.60	2.80	3.80	3.80	2.90	4.05	3.65	3.7
	3.55	4.25	5.20	8.25	3.50	2.75	3.65	3.65	3.68	3.90	3.55	4.05
	3.40	4.40	5.75	6.98	3.40	2.70	3.60	3.55	3.55	3.98	3.5	4.4
	3.30	4.50	9.10	6.48	3.30	2.65	3.55	3.55	3.28	5.08	3.55	4.13
	3.30	4.70	9.20	5.50	3.28	2.78	2.95	3.45	3.40	4.60	3.63	4.0
	3.30	4.95	7.50	4.95	3.23	2.75	2.80	3.15	3.53	4.25	3.53	4.0
	3.20	3.10	5.45	4.78	3.20	2.70	2.80	3.20	3.35	4.15	3.5	3.95
	3.30	3.20	7.40	4.58	3.05	2.75	2.75	3.15	3.18	4.25	3.4	4.53
	3.20	3.40	9.43	4.35	3.00	2.90	2.70	3.05	3.05	3.98	3.4	6.35
	3.00	3.50	6.85	4.25	2.95	2.88	2.65	2.93	2.95	3.83	3.33	5.43
	2.90	3.60	4.15	4.20	2.90	2.78	2.70	3.05	2.98	3.80	3.3	5.0
	2.90	3.80	4.50	4.20	2.95	2.85	4.40	3.10	3.25	3.83	3.28	4.80
	3.10	3.80	4.00	4.13	2.95	2.80	7.25	3.03	3.48	3.73	3.30	6.65
	9.85	3.80	4.55	4.10	2.83	2.80	6.50	2.98	3.58	3.73	3.2	8.48
	5.90	3.50	5.58	4.03	2.78	2.80	6.53	2.93	3.18	3.60	3.2	6.7
	4.80	3.20	5.48	3.95	2.90	2.78	6.18	2.83	3.10	3.63	3.15	5.13
	4.40	3.40	5.05	3.90	2.95	2.70	7.08	2.75	3.25	3.60	3.2	4.85
	4.03	3.50	4.93	3.80	2.85	2.68	.....	2.70	3.58	3.50	3.3	6.65
	3.85	4.83	4.83	3.83	3.10	2.65	4.05	2.70	4.35	3.55	3.85	4.35
	3.58	9.15	5.03	3.73	3.33	2.60	4.20	2.73	a4.70	5.90	4.13	4.20
	3.70	.....	5.73	3.95	3.25	2.80	4.40	2.85	9.95	5.30	3.8	4.13
	4.25	.....	5.98	4.10	3.13	3.88	4.38	2.98	7.20	4.70	3.63	3.95
	4.30	.....	5.43	.....	3.00	.....	4.25	3.08	.....	4.45	.....	3.85

a Gage height at 12 p. m.=16.1 feet.

RONDOUT CREEK AT ROSENDALE, N. Y.

This station was established at the highway bridge in Rosendale, miles above the junction of Rondout Creek and Wallkill River, uly 6, 1901. The station is described and results of gagings for 1901 re given in Water-Supply Paper No. 65, pages 66 to 68. Gage read-ıgs taken during the extreme freshets of December 15, 1901, and larch 1, 1902, are as follows:

'age heights of Rondout Creek at Rosendale, N. Y., during freshets of December 15, 1901, and March 1, 1902.

Date.	A. M.	M.	P. M.
1901.			
December 15	15.75	16.7	17.8
1902.			
March 1	17.4	.....	17

The following table gives the discharge measurements made on Rondout Creek at Rosendale, N. Y., during 1902:

Discharge measurements of Rondout Creek at Rosendale, N. Y.

Date.	Hydrographer.	Gage height.	Discharge
1902.		*Feet.*	*Second-feet.*
September 25	P. M. Churchill	6.31	1[illegible]
July 15	H. K. Barrows	6.33	1[illegible]
July 18	do	6.33	1[illegible]
August 29	do	6.33	1[illegible]
June 6	W. W. Schlecht	6.38	1[illegible]
June 20	do	6.42	1[illegible]
November 21	F. H Tillinghast	6.55	2[illegible]
December 2	do	6.70	2[illegible]
April 28	W. W. Schlecht	6.83	2[illegible]
May 12	do	6.85	2[illegible]
November 4	F. H. Tillinghast	7.00	3[illegible]
August 7	H. K. Barrows	7.39	4[illegible]
July 29	do	7.40	4[illegible]
March 21	W. W. Schlecht	8.07	1,5[illegible]
March 1	do	17.60	13,9[illegible]
April 11	do	11.78	5,6[illegible]
December 17	F. H. Tillinghast	12.80	7,9[illegible]

Additional measurements were made by W. W. Schlecht while the river was frozen over, as follows:

February 18: Gage height, 7.70; discharge, 342 second-feet. The river was frozen over from bank to bank and slush had collected below the ice.

February 26: Gage height, 8.13; discharge, 543 second-feet. Slush below the ice made an unsatisfactory record.

February 26: Gage height, 8.43; discharge, 684 second-feet. Ice covered the river from bank to bank and slush had collected underneath.

Mean daily gage height, in feet, of Rondout Creek at Rosendale, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	8.73	8.98	17.20	8.18	8.25	6.58	7.08	7.70	6.25	10.03	7.25	6.73
	7.90	8.95	14.23	7.85	7.70	6.48	6.90	8.35	6.20	9.28	7.05	6.70
	7.90	9.75	12.53	7.58	7.70	6.55	6.98	7.60	6.13	8.43	7.03	6.90
	7.90	9.35	9.75	7.58	7.75	6.63	7.70	7.28	6.15	7.90	7.00	7.20
	7.90	9.70	8.70	7.35	7.50	6.48	7.23	7.08	6.10	7.80	6.90	6.88
	7.83	9.25	8.05	7.25	7.33	6.40	7.13	7.25	6.18	8.78	6.87	6.80
	7.58	9.00	7.95	7.60	7.28	6.48	7.00	7.33	6.20	8.00	6.95	6.95
	7.28	8.83	7.65	8.10	7.15	6.45	6.88	7.03	6.20	7.65	6.85	6.98
	7.13	8.58	9.40	12.28	7.03	6.48	6.85	6.93	6.23	7.38	6.80	6.88
	7.08	8.05	9.70	11.40	6.93	6.38	6.68	6.83	7.00	7.18	6.78	7.10
	7.10	8.18	9.30	9.75	6.88	6.30	6.58	6.80	6.58	6.95	6.73	7.08
	7.35	8.05	9.70	9.15	6.88	6.35	6.53	6.90	6.40	9.75	6.73	7.00
	6.95	7.98	11.05	8.63	6.83	6.35	6.50	6.80	6.45	8.65	6.73	6.95
	6.73	7.88	10.15	8.15	6.68	6.38	6.45	6.70	6.68	8.00	6.70	7.15
	6.83	7.80	9.15	7.85	6.63	6.35	6.35	6.55	6.48	7.57	6.70	7.50
	6.90	7.65	8.80	7.65	6.70	6.35	6.40	6.58	6.35	7.35	6.70	8.35
	6.78	7.53	13.10	7.50	6.60	6.50	6.33	6.50	6.25	7.23	6.65	12.95
	6.70	7.60	9.95	7.38	6.63	6.45	6.30	6.45	6.20	7.07	6.65	10.00
	6.78	7.35	8.65	7.25	6.60	6.30	6.33	6.40	6.18	7.07	6.68	8.80
	6.70	7.43	8.25	7.18	6.60	6.43	7.53	6.40	6.25	7.00	6.65	8.30
	6.73	7.43	8.08	7.10	6.58	6.43	8.93	6.38	6.50	6.95	6.65	8.35
	14.68	7.40	8.00	7.05	6.50	7.10	9.18	6.48	6.40	6.90	6.65	13.45
	9.83	7.43	7.88	7.00	6.48	6.70	8.38	6.40	6.23	6.80	6.60	10.58
	8.35	7.48	7.80	6.90	6.45	6.50	[a]9.94	6.40	6.25	6.80	6.60	9.55
	7.85	7.55	7.63	6.88	6.40	6.40	10.34	6.33	6.45	6.80	6.55	8.50
	7.68	8.23	7.45	6.98	6.80	6.43	8.95	6.30	9.40	6.73	6.70	8.10
	8.95	10.68	7.38	6.95	6.88	6.50	8.23	6.28	9.75	6.63	6.75	8.87
	7.75	12.10	7.33	6.83	7.20	6.43	7.80	6.25	8.68	9.38	6.90	7.45
	8.00	.....	9.85	6.78	6.85	6.45	7.38	6.33	[b]14.90	8.60	6.88	7.27
	8.18	.....	9.53	9.38	6.60	7.70	7.80	6.30	10.78	7.83	6.80	7.20
	8.60	.....	8.63	.....	6.63	.....	7.33	6.30	.....	7.45	.....	7.20

[a] Highest water, 12.65, at 7 p. m. [b] Highest water, 15.6, at 3 p. m.

DELAWARE AND HUDSON CANAL AT CREEKLOCKS, N. Y.

The Delaware and Hudson Canal runs parallel to Rondout Creek from the feeder dam below High Falls to tide water at Eddyville. The canal receives its entire water supply from Rondout Creek. The section from High Falls to Eddyville is the only portion of the canal remaining in operation in New York State. At Rosendale the canal carries a portion of the yield of Rondout Creek past the gaging station. In order to determine the run-off from Rondout Creek drainage basin, gagings of the flow in the Delaware and Hudson Canal at the foot of the Rosendale level have been undertaken. The diversion to the canal added to the measured discharge of Rondout gaging station represents the total flow from the drainage basin. The gaging station at Creeklocks is described in Water-Supply Paper No. 65, pages 68 to 69. The accompanying table shows the estimated daily and mean monthly diversion during 1902.

Estimated diversion, in second-feet, from Rondout Creek to Delaware and Hud... Canal, Rosendale, N. Y.

Day.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	De
1902.										
1		15.5	22.6		24.2	26.0		22.6	22.5	
2		17.7	15.0	25.2	23.8	25.6	25.3	22.4		
3		21.5	24.6	20.8	23.1		22.5	26.1	21.0	
4		22.0		11.6		23.8	24.3	25.8	23.5	
5		17.9	27.6	25.3	24.1	24.5	25.3		21.5	
6			23.1	19.5		22.5	25.8	22.2	23.3	
7		20.4	24.8	21.8	23.1	24.5		23.1	24.2	
8		20.2	24.3		22.7	23.8	25.0	22.4	24.4	
9		18.4	24.6	23.8	24.3	24.0	23.5	21.9		
10		14.3	24.5	25.9	25.3		24.3	22.8	22.8	
11		20.7		24.9	26.1	24.0	24.3	22.1	21.7	
12		19.2	24.3	23.8	21.8	24.5	25.1			
13			24.1	27.5		24.6	22.2	20.4	21.2	
14		25.4	25.0	23.6	25.3	26.0		20.6	21.0	
15		25.7	24.1		25.3	24.8	26.5	20.5	21.3	
16		24.2	24.5	22.3	24.2	24.5	25.6	19.5		
17		25.1	22.8	22.6	26.0		25.8	19.5	21.6	
18		26.1		24.3	25.1	25.5	23.3	19.7	24.8	
19		25.6	24.3	23.8	22.7	24.3	24.8		23.8	
20			24.6	23.9		23.8	22.0	21.3	20.4	
21		25.9	23.1	24.4	23.8	25.1		23.5	26.0	
22		26.7	23.6		25.6	25.6	24.3	21.0	21.8	
23	15.8	24.1	25.6	22.1	22.8	24.3	23.8	21.2		
24	11.4	23.3	24.3	20.1	20.6		24.0	23.0	23.0	
25	12.3	23.4		22.6	19.0	22.8	25.1	20.4	21.2	
26	15.3	22.8	21.1	22.8	22.8	22.2	22.8		21.7	
27	16.9		26.0	19.8		25.1	22.6	22.8	22.7	
28	16.4	27.1	26.5	22.6	25.6	22.5		23.8	24.8	
29		25.2	26.3		21.6	25.8	20.3	24.3	22.5	
30		25.8	20.7	26.7	23.6	23.0	22.1	23.0		
31	21.8		24.1		26.4			25.0		
Mean		22.5	24.0	23.7	23.8	24.3	24.0	22.2		

[a] Close of navigation.

RONDOUT CREEK AT HONK FALLS, N. Y.

This gaging station is described in Water-Supply Paper No. ... pages 69 to 70. Automatic recording gages have been erected at ... dam and power house. The gages furnish continuous graphic ... charts, showing the depth wasted over the dam and the flow over ... weir situated in the tailrace of the power house of the Honk Fa... Light and Power Company. The discharge has not been estimate...

WALLKILL RIVER AT NEWPALTZ, N. Y.

Wallkill River rises in the northern highlands of New Jersey. T... greater portion of its course lies through New York State, and it ... tributary to the Hudson River through Rondout Creek. The gag... station at Newpaltz, which was established July 7, 1901, is descri... in Water-Supply Paper No. 65, pages 71 to 74. The drainage basin ... less precipitous than that of other streams in southeastern New Yor... Wallkill River, however, closely resembles Catskill and Esop...

eeks in the torrential character of its run-off, being subject to sudn and extreme variations in flow. The maximum gage readings ve been as follows:

Maximum gage heights of Wallkill River at Newpaltz.

Date.	A. M.	P. M.
1901.	*Feet.*	*Feet.*
cember 15	13.5	13.1
cember 30	18.0	20.5
cember 31	19.7	18.7
1902.		
arch 1	22.4	24.65
arch 2	23.6	24.0
arch 3	24.8	24.5
cember 22	17.4	20.6
cember 23	20.6	18.7

The following table gives a list of the discharge measurements ade on the Wallkill River at Newpaltz, N. Y., during 1902:

Discharge measurements of Wallkill River at Newpaltz, N. Y.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
ıly 17	H. K. Barrows	5.70	124.3
ugust 28	do	5.86	169.0
ptember 18	Barrows and Churchill	5.96	209.5
ıne 19	W. W. Schlecht	6.18	295.0
ay 21	do	6.33	344.0
ıne 6	do	6.40	381.0
ovember 18	F. H. Tillinghast	6.62	550.0
ay 13	W. W. Schlecht	6.68	506.0
ugust 15	H. K. Barrows	6.72	518.0
ecember 2	F. H. Tillinghast	6.80	626.0
pril 26	W. W. Schlecht	6.92	680.0
ebruary 24	do	7.33	[a]288.0
ıly 29	H. K. Barrows	7.49	942.0
pril 21	W. W. Schlecht	7.57	1,028.0
ebruary 10	do	7.78	[b]597.0
ovember 4	F. H. Tillinghast	7.95	1,165.0
ugust 6	H. K. Barrows	7.98	1,150.0
ay 1	W. W. Schlecht	10.264	2,623.0
pril 9	do	13.21	5,354.0
arch 11	do	15.93	7,140.0

[a] Measured through ice 1 foot and 6 inches to 2 feet and 6 inches in thickness.
[b] Measured through ice 1 foot to 2 feet in thickness.

Mean daily gage height, in feet, of Wallkill River at Neerpaltz, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	De
1902.												
1	15.15	8.75	23.53	9.35	10.25	7.50	7.25	9.50	6.10	10.25	8.6	
2	13.10	8.75	23.80	8.95	8.95	7.25	7.15	9.10	6.05	10.85	8.35	
3	12.95	10.65	[a]24.65	8.65	9.15	7.05	7.80	8.75	6.00	10.15	8.15	
4	12.10	9.70	22.75	8.20	8.85	6.90	7.58	8.60	5.88	9.65	7.95	
5	10.45	9.75	20.25	8.00	8.35	6.55	7.08	8.30	5.78	9.40	7.65	
6	10.70	8.90	15.20	9.70	7.95	6.35	6.78	7.95	5.70	10.10	7.50	
7	10.20	8.15	13.20	7.70	7.50	6.30	6.58	7.85	5.60	9.45	7.30	
8	9.70	7.85	12.70	8.40	7.45	6.25	6.35	7.65	5.50	9.00	7.05	
9	9.15	7.78	14.95	[b]13.65	7.35	6.30	6.23	7.30	5.50	8.55	7.15	
10	8.85	7.70	16.45	13.50	7.10	6.50	6.32	7.05	6.10	8.40	6.95	
11	8.75	7.55	15.90	12.20	6.80	6.35	6.00	6.90	6.45	8.25	6.75	
12	8.20	7.55	16.10	11.65	6.65	6.30	6.00	6.80	6.30	12.45	6.7	
13	8.05	7.40	17.05	10.65	6.60	6.20	5.90	6.75	6.35	11.90	6.6	
14	8.05	7.35	16.50	9.80	6.55	6.15	5.78	6.68	6.45	10.50	6.6	
15	8.00	7.15	15.00	9.35	6.50	6.10	5.70	6.60	6.25	9.70	6.6	
16	8.00	7.10	14.65	8.65	6.45	6.20	5.70	6.53	6.15	9.35	6.5	
17	7.70	7.20	15.40	8.20	6.45	6.25	5.73	6.43	6.05	9.00	6.5	
18	7.55	7.15	13.75	8.00	6.30	6.15	5.58	6.38	5.95	8.60	6.5	
19	7.50	7.08	11.75	7.85	6.30	6.13	5.55	6.28	5.80	8.60	6.5	
20	7.20	7.00	10.50	7.60	6.30	6.10	6.10	6.20	5.90	8.15	6.5	
21	7.20	7.05	10.30	7.45	6.30	6.13	7.50	6.30	5.90	7.95	6.4	
22	18.50	7.05	10.20	7.35	6.30	6.33	8.65	6.10	5.90	7.65	6.4	
23	17.65	7.10	9.75	7.15	6.25	6.40	7.40	6.05	5.90	7.47	6.65	
24	13.55	7.25	9.60	7.10	6.20	6.35	[c]10.70	6.10	5.90	7.37	6.3	
25	13.15	7.30	9.45	6.95	6.20	6.20	[d]14.00	6.05	6.15	7.15	6.3	
26	12.20	7.75	9.00	6.85	6.45	6.20	9.10	6.00	9.65	6.95	6.35	
27	12.85	11.40	8.50	7.00	8.30	6.10	8.50	6.00	12.00	6.85	6.35	
28	12.65	12.75	8.20	6.45	9.20	6.25	7.80	5.95	11.90	11.65	6.35	
29	11.06	.....	10.20	6.65	8.40	6.35	7.45	8.25	13.45	11.25	7.1	
30	9.50	.....	11.05	[e]11.75	8.30	7.00	7.45	7.25	10.35	9.45	6.95	
31	9.25	.....	9.90	.....	7.90	.....	8.45	6.40	.....	8.95	.....	

[a] Highest water 24.80 at (?) p. m.
[b] Highest water 14.6 at (?) p. m.
[c] Highest water 15.4 at 8 p. m.
[d] Highest water 16.6 at 9 p. m.
[e] Highest water 12.6 at p. m.

FISHKILL CREEK AT GLENHAM, N. Y.

The gaging station is located at the Newburg, Dutchess and Connecticut Railroad bridge in Glenham. It was established July 8, 1901, and is described in Water-Supply Paper No. 65, pages 74 to 76, where discharge measurements and gage heights for 1901 may be found. The following table gives a list of the discharge measurements made on the Fishkill Creek at Glenham, N. Y., during 1902:

Discharge measurements of Fishkill Creek at Glenham, N. Y.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Sec. feet.*
August 26	H. K. Barrows	3.04	48.5
July 14	do	3.18	64.4
August 11	do	3.51	115.0
November 25	F. H. Tillinghast	3.65	146.0
October 11	P. M. Churchill	3.71	155.0
June 2	W. W. Schlecht	3.785	132.3
July 28	H. K. Barrows	3.90	200.0
June 17	W. W. Schlecht	4.00	212.5
November 8	F. H. Tillinghast	4.00	233.0
April 25	W. W. Schlecht	4.03	[a] 152.4
May 6	do	4.46	349.5
February 11	do	4.87	[b] 202.5
October 30	C. C. Covert	4.97	697.7
April 12	W. W. Schlecht	5.30	772.6
March 5	do	5.79	1,129.0

[a] Probably incorrect.

[b] Ice along banks at gaging station, frozen from bank to bank 90 yards below station, 2 to 9 inches thick.

Mean daily gage height, in feet, of Fishkill Creek at Glenham, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	6.05	5.00	13.00	4.90	5.48	3.83	3.70	3.80	2.90	4.25	4.00	
2	5.65	4.75	10.00	4.78	4.93	3.70	3.53	3.70	2.80	4.20	4.35	
3	5.50	5.63	8.78	4.68	4.70	3.60	3.45	3.60	2.95	4.00	4.20	
4	5.30	5.55	6.70	4.60	4.73	3.70	3.85	3.60	2.73	3.83	4.15	
5	5.18	5.58	5.80	4.53	4.63	3.70	3.60	3.50	2.90	3.83	4.05	
6	4.95	5.28	4.95	4.45	4.45	3.55	3.70	3.43	2.95	4.20	4.00	
7	4.80	5.25	5.05	4.53	4.35	3.50	3.70	3.48	2.90	4.20	4.00	
8	4.70	5.00	5.15	4.63	4.30	3.85	3.55	3.40	2.95	3.93	4.00	
9	4.65	5.18	5.90	5.13	4.20	3.85	3.45	3.40	3.00	3.85	3.95	
10	4.63	5.05	7.75	5.65	4.10	3.75	3.38	3.30	3.33	3.78	3.9	
11	4.60	4.75	6.95	5.53	3.90	3.60	3.40	3.50	3.25	3.70	3.8	
12	4.58	4.80	6.50	5.28	3.98	3.50	3.30	3.85	3.08	4.05	3.8	
13	4.75	4.60	6.70	5.05	3.95	3.40	3.23	3.65	3.30	5.03	3.8	
14	5.00	4.40	6.63	4.90	3.90	3.43	3.20	3.48	3.23	4.08	3.8	
15	4.70	4.33	5.98	4.80	3.90	3.50	3.13	3.40	3.20	4.35	3.8	
16	4.85	4.25	5.65	4.70	3.90	3.50	3.13	3.35	3.15	4.20	3.8	
17	4.28	4.48	6.73	4.60	3.80	3.95	3.10	3.28	3.15	4.80	3.8	
18	4.25	4.38	6.45	4.58	3.70	3.70	3.10	3.20	3.18	4.00	3.7	
19	4.25	4.33	5.70	4.50	3.75	3.50	3.08	3.20	3.00	4.00	3.7	
20	4.18	4.35	5.20	4.40	3.80	3.53	3.20	3.15	3.05	3.95	3.6	
21	4.18	4.38	5.30	4.35	3.83	3.50	4.15	3.10	3.03	3.90	3.63	
22	5.88	4.35	5.23	4.30	3.68	3.75	4.70	3.15	3.15	3.80	3.6	
23	6.55	4.35	5.13	4.23	3.68	3.60	4.65	3.10	3.08	3.80	3.6	
24	5.15	4.90	5.00	4.15	3.60	3.50	4.10	3.10	3.13	3.70	3.6	
25	4.75	4.70	4.85	4.05	3.60	3.40	4.18	3.15	2.95	3.75	3.6	
26	4.63	4.85	4.75	4.05	4.20	3.50	4.10	3.05	3.48	3.73	3.6	
27	5.00	5.88	4.70	4.13	4.15	3.40	4.05	3.00	3.60	3.70	3.5	
28	5.00	7.10	4.55	4.08	4.58	3.30	3.90	3.00	3.60	4.65	3.8	
29	4.95	.....	4.85	4.00	4.23	3.35	3.80	2.95	4.80	5.43	3.8	
30	5.05	.....	5.40	4.83	4.03	4.08	4.20	2.95	4.75	4.98	3.7	
31	4.95	.....	5.05	.....	3.90	.....	3.95	2.90	.....	4.55	.....	

The freshet of March 1, 1902, exceeded all previous high-water records.

Height of Fishkill Creek during freshet of March 1, 1902.

7.45 a. m	13.6
11 a. m	14.5
4.45 p. m	12.4

The following table of discharge has been calculated from high-ter marks observed for a number of years at the Groveville dam. ie dam is of masonry, plank faced, has a straight horizontal crest 4 et wide and 134 feet long. The discharge has been calculated by eans of coefficients for the weir formula derived from Cornell periment No. 11:

Flood discharge of Fishkill Creek above Groveville dam.

Date.	Year.	Depth on plank crest.	Discharge.	Run-off per square mile.
		Feet.	*Second-feet.*	*Second-feet.*
ptember 24	1882	6.33	7,700	38.5
arch 22	1888	5.0	5,200	26.0
cember 18	1888	4.5	4,400	22.0
nuary 12	1891	6.33	7,700	38.5
nuary 13	1891	4.0	3,650	18.25
nuary 22	1891	4.0	3,650	18.25
nuary 23	1891	6.92	8,800	44.00
arch 10	1893	5.0	5,200	26.0
arch 11	1893	4.25	4,000	20.0
arch 12	1893	5.5	6,100	30.5
arch 13	1893	5.0	5,200	26.0
arch 14	1893	4.0	3,650	18.25
ebruary 7	1896	6.67	8,300	41.5
arch 1	1896	4.5	4,400	22.0
arch 20	1896	6.67	8,300	41.5
arch 1	1902	9.5	13,700	68.5

The drainage area above the Groveville dam is 200 square miles. The intensity of the freshet of March 1, 1902, on lower Fishkill Creek was probably increased by the formation and later tearing away of an ice blockade on the flood plain opposite Fishkill village.

A measurement of the low-water flow of Clove Creek, the largest tributary of Fishkill Creek, entering near Fishkill village, was made near the mouth of the stream September 24, 1902. The discharge was 3.5 second-feet from a drainage area of 20 square miles, or 0.18 second-foot per square mile.

TENMILE RIVER NEAR DOVER PLAINS, N. Y.

The gaging station is located at Tabor's bridge, 2 miles below Dover Plains village. It was established September 16, 1901, and is described in Water-Supply Paper No. 65, pages 85 to 87, where the results of discharge measurements and daily gage heights for 1901 are given. The stream is tributary to Housatonic River near Gaylordsville, Conn.

The following table gives a list of the discharge measurements made on the Tenmile River at Dover Plains, N. Y., during 1902:

Discharge measurements of Tenmile River at Dover Plains, N. Y.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
September 2	H. K. Barrows	3.95	6[illegible]
August 19	do	4.28	[illegible]
June 10	W. W. Schlecht	4.45	[illegible]
February 13	do	4.67	[illegible]
August 4	H. K. Barrows	4.69	18[illegible]
November 28	F. H. Tillinghast	4.80	[illegible]
November 14	do	4.87	[illegible]
May 15	W. W. Schlecht	4.88	[illegible]
June 30	do	4.92	[illegible]
May 28	do	5.50	[illegible]
October 2	P. M. Churchill	5.80	[illegible]
April 15	W. W. Schlecht	6.13	[illegible]
April 7	do	6.18	[illegible]
May 2	do	6.46	[illegible]
July 21	H. K. Barrows	7.18	[illegible]
December 19	F. H. Tillinghast	8.28	1,[illegible]
March 3	W. W. Schlecht	10.41	2,[illegible]

[a] River nearly covered with ice from bank to bank and 1½ to 2½ inches thick.

Mean daily gage height, in feet, of Tenmile River at Dover Plains, N. Y.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
...	7.70	5.40	14.15	6.60	6.95	4.55	4.45	5.10	3.90	5.78	5.75	4.45
...	7.00	6.10	14.10	6.45	6.95	4.50	4.25	4.88	3.83	5.85	5.50	4.48
...	6.95	6.95	[a]11.43	6.25	6.50	4.40	4.35	4.65	3.80	5.43	5.43	4.8
...	6.10	6.08	8.35	5.98	6.20	4.55	5.53	4.63	5.90	5.10	5.33	4.90
...	6.08	5.50	6.95	5.80	6.05	4.48	4.38	4.53	3.83	5.30	5.30	4.78
...	6.15	5.35	5.90	5.90	5.90	4.35	4.60	4.43	3.80	5.85	5.25	4.78
...	6.10	5.10	6.25	6.13	5.75	4.25	4.63	4.65	3.85	5.38	5.10	4.8
...	5.80	5.10	6.25	6.40	5.55	4.48	4.33	4.60	3.88	5.13	5.08	4.85
...	5.65	4.95	8.90	6.80	5.35	4.55	4.38	4.45	3.95	4.90	5.0	5.13
...	5.55	4.90	10.60	7.60	5.23	4.48	4.23	4.43	4.23	4.83	4.93	5.08
...	5.60	5.10	9.15	7.10	4.95	4.30	4.20	5.68	3.95	5.00	4.83	4.85
...	5.55	5.10	8.70	6.60	4.85	4.20	4.10	5.03	3.90	6.10	4.78	4.8
...	5.38	4.80	9.10	6.30	4.85	4.75	4.15	4.95	4.10	6.83	4.83	4.8
...	5.25	6.75	8.40	6.15	4.80	4.70	3.90	4.78	4.23	5.87	4.8	4.98
...	5.25	5.25	7.70	6.10	4.80	4.35	3.88	4.68	4.13	5.63	4.83	5.08
...	4.98	5.15	7.30	5.90	4.75	4.45	4.30	4.23	4.08	5.48	4.73	6.15
...	4.65	5.05	8.15	5.88	4.65	4.65	4.18	4.18	3.88	5.25	4.65	10.47
...	5.05	5.05	7.60	5.68	4.60	4.45	3.88	4.15	3.88	5.15	.....	9.13
...	5.10	5.00	6.55	5.58	4.65	4.28	4.03	4.15	4.03	5.27	4.6	8.28
...	5.05	4.85	6.13	5.45	4.68	4.15	4.65	4.18	4.28	5.20	4.53	7.7
...	5.05	4.75	6.10	5.35	4.58	4.40	6.98	4.25	4.33	4.90	4.55	7.74
...	11.95	4.68	6.15	5.23	4.50	4.60	7.15	4.23	4.13	4.80	4.58	11.5
...	8.10	4.40	6.20	5.13	4.40	4.38	6.35	4.10	4.15	4.75	4.55	10.65
...	6.35	4.50	6.25	5.03	4.30	4.33	5.75	4.08	4.08	4.73	4.53	8.58
...	5.80	4.65	6.05	4.95	4.30	4.15	5.68	4.08	4.05	4.65	4.58	7.95
...	5.70	5.83	5.90	4.95	5.05	4.10	5.50	3.98	4.08	4.55	4.7	7.48
...	7.80	8.45	5.85	5.30	5.30	4.05	5.30	3.98	4.65	4.60	4.93	7.05
...	7.45	9.73	7.43	5.25	5.50	4.05	5.40	3.85	6.50	7.05	4.78	6.63
...	6.55	.....	7.60	5.30	5.18	4.10	5.25	3.83	7.75	7.10	4.65	6.50
...	6.25	.....	7.30	7.00	4.80	4.70	5.65	3.80	5.98	6.37	4.53	6.55
...	5.50	.....	6.90	.....	4.70	.....	5.25	3.85	.....	6.00	.....	6.55

[a] Readings on new gage. From this date datum 0.33 above former gage-zero.

HOUSATONIC RIVER AT GAYLORDSVILLE, CONN.

This gaging station was established October 24, 1900, and is situated on the Housatonic about 2 miles below the point of inflow of Tenmile River. Discharge measurements are made from a cableway of 200 feet span placed across the stream 1¼ miles below the gage. The station is described and the results of gagings for preceding years are given in Water-Supply Paper No. 65, pages 87 to 90.

The following is a list of the discharge measurements made on the Housatonic River at Gaylordsville, Conn., during 1902.

Discharge measurements of Housatonic River at Gaylordsville, Conn.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
September 8	H. K. Barrows	3.45	34
September 19	Barrow & Churchill	3.75	64
August 20	H. K. Barrows	3.95	[illegible]
August 5	do	4.28	9[illegible]
July 11	do	4.30	1,1[illegible]
November 29	F. H. Tillinghast	4.40	1,2[illegible]
June 23	W. W. Schlecht	4.46	1,1[illegible]
November 15	F. H. Tillinghast	4.50	1,2[illegible]
October 3	P. M. Churchill	5.35	2,1[illegible]
May 3	W. W. Schlecht	6.10	4,1[illegible]
December 20	F. H. Tillinghast	6.65	5,4[illegible]
July 22	H. K. Barrows	6.68	5,[illegible]
March 18	W. W. Schlecht	7.63	8,[illegible]
March 4	do	9.9	13,8[illegible]

Mean daily gage height, in feet, of Housatonic River at Gaylordsville, Conn.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	De
1902.												
1	7.10	4.90	14.30	6.80	6.80	4.70	4.80	4.80	3.80	5.50	5.30	4.1
2	6.50	4.90	10.80	6.60	6.80	4.40	4.60	4.65	3.55	5.50	5.30	4.1
3	5.90	5.40	9.90	6.80	6.10	4.40	4.40	4.65	3.50	5.25	5.00	4.0
4	5.30	4.90	10.20	5.80	5.90	4.60	4.70	4.45	3.60	5.15	4.95	4.0
5	5.20	4.80	7.80	5.80	5.60	4.90	4.50	4.30	3.65	5.00	4.85	4.0
6	5.30	4.60	6.80	5.50	5.50	4.80	4.50	4.40	3.55	5.15	4.75	4.0
7	5.30	4.50	6.50	5.50	5.50	4.60	4.80	4.60	3.65	5.00	4.65	4.0
8	5.20	4.40	6.80	5.70	5.30	4.60	5.00	4.55	3.50	4.85	4.60	4.0
9	5.30	8.50	6.80	6.10	5.20	4.40	4.70	4.55	3.55	4.70	4.5	3.9
10	5.10	6.80	7.50	6.80	4.90	4.60	4.50	4.45	4.00	4.55	4.35	3.8
11	5.00	7.00	7.20	6.90	5.00	4.50	4.40	4.50	4.00	4.40	4.3	3.7
12	4.90	8.00	7.70	6.80	4.90	4.50	4.30	5.15	3.90	5.30	4.45	3.7
13	4.70	8.80	7.80	6.80	4.90	4.40	4.20	5.00	3.85	5.30	4.4	4.
14	4.30	8.30	8.00	6.70	4.80	4.70	4.00	4.70	4.10	5.10	4.5	4.1
15	4.50	8.00	7.90	6.20	4.70	4.60	3.90	4.50	4.00	5.00	4.5	4.2
16	4.50	7.10	7.70	5.90	4.60	4.30	4.10	4.35	3.60	4.80	4.4	4.9
17	4.30	6.80	7.90	5.80	4.60	4.50	4.20	4.20	3.70	4.75	4.35	7.9
18	4.20	7.00	7.60	5.60	4.50	4.40	3.90	4.00	3.75	4.60	4.25	7.5
19	4.40	7.50	7.30	5.60	4.40	4.40	3.80	3.80	3.80	4.55	4.3	6.7
20	4.20	7.30	7.00	5.50	4.30	4.40	4.65	4.05	3.85	4.25	4.25	6.5
21	4.50	7.20	6.60	5.20	4.60	4.30	6.00	3.95	4.05	4.30	4.3	6.2
22	8.50	7.20	6.60	5.20	4.40	4.70	6.60	4.05	3.75	4.45	4.2	5.9
23	6.80	6.80	6.10	5.10	4.30	4.50	6.00	4.10	3.60	4.40	4.2	5.4
24	6.30	6.50	5.90	5.10	4.10	4.30	5.70	4.10	3.70	4.45	4.05	7.5
25	5.80	6.80	6.00	5.00	4.20	4.30	5.50	3.95	3.65	4.45	4.15	7.1
26	5.60	7.00	6.00	4.90	4.50	4.30	5.30	3.95	3.85	4.40	4.25	6.9
27	5.90	10.60	5.90	5.00	4.60	4.20	4.95	3.95	4.20	4.30	4.6	6.6
28	5.70	9.00	5.90	5.10	5.30	4.20	4.85	3.95	4.60	5.85	4.5	6.
29	5.30	.....	6.70	5.10	5.30	4.10	5.55	3.90	6.30	6.55	4.4	5.7
30	4.90	.....	6.70	6.20	5.00	4.30	5.45	3.90	6.00	6.00	4.25	5.9
31	4.90	.....	6.70	.....	4.70	.....	5.40	3.70	.....	5.80	.....	5.9

PASSAIC RIVER DRAINAGE BASIN.

Passaic River has its rise in Somerset and Morris counties, N. J. bove its confluence with Pompton River, its main tributary, it anders through a flat country of Triassic red sandstones, to which large measure must be attributed the turbidity of its waters. In ntrast with the sluggish, muddy character of the Passaic, the mpton is a rapid stream and its waters are clear. It drains parts Sussex, Passaic, and Morris counties, and traverses for a large part its course a country of hard crystalline rocks and heavy forests, e general level of which is several hundred feet above that of the assaic. At their confluence the Pompton enters with a current hich carries it well toward the right bank of the Passaic, and at mes of flood causes much backwater in the latter.

The flow of Passaic River is of special interest from the fact that veral large cities in its drainage basin take their public water sup- ly from it, and because of the valuable water-power privileges along s course, particularly at the city of Paterson. Several cities, includ- ig Paterson and Passaic, throw their sewage into this stream, and in ie lower part of its course it becomes so polluted as to be offensive) property holders along its banks and to seriously interfere with ie comfort and pleasure of the inhabitants of several towns.

Measurements of the flow over the dam at Paterson have been made or several years, but the data are not available for publication.

The United States Geological Survey has a gaging station on the assaic River at Two Bridges, New Jersey, and also on the Pompton iver at the same place. These stations are under the supervision f George B. Hollister.

The highest recorded flood occurring on these watersheds is that f February and March, 1902, the estimated discharge at Dundee lam being 24,800 second-feet. The next highest occurred on Septem- ber 22 to 30, 1882, when the estimated discharge was 18,265 second- eet. These floods will be fully described in a forthcoming paper.

POMPTON RIVER AT TWO BRIDGES, NEW JERSEY.

A station was established May 2, 1901, by George B. Hollister, on Pompton River just above its junction with Passaic River, a point 2 miles south of the railway station at Mountain View, N. J., and 2½ miles west of Littlefalls, N. J. Measurements are made from a wagon bridge. The gage is a vertical pine board, marked in feet and tenths, spiked to the middle masonry pier on the downstream side. The bench mark is the top of the capstone of the same pier, and its elevation is 10.7 feet above the datum of the gage. The channel, which is gravelly, is straight for some distance above and below the bridge, the banks on both sides being about 8 feet high and subject to overflow at times of freshets only.

The flood of February–March, 1902, is considered the highest that has been recorded.

The following discharge measurements were made during 1902 by George B. Hollister:

January 17: Gage height, 1.55 feet; discharge, 475 second-feet.
March 1: Gage height, 11.70 feet; discharge, 8,023 second-feet.
May 30: Gage height, 2.10 feet; discharge, 556 second-feet.
June 18: Gage height, 1.30 feet; discharge, 189 second-feet.
September 11: Gage height, 1.50 feet; discharge, 170 second-feet.

Daily gage height, in feet, of Pompton River at Two Bridges, New Jersey.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	De.
1902.												
1	8.35	3.00	10.40	4.35	3.30	2.15	2.50	2.75	1.30	4.55	2.75	
2	7.55	3.50	14.40	4.15	3.05	1.75	2.25	2.65	1.20	4.95	2.70	
3	6.45	3.70	14.00	3.40	2.80	1.30	2.00	2.55	1.10	4.70	2.70	
4	6.25	3.50	10.80	3.25	2.95	1.30	2.10	2.30	1.10	4.45	2.65	
5	5.15	3.40	9.75	3.15	2.55	1.20	2.00	2.10	1.10	4.45	2.35	
6	4.00	3.30	8.40	3.00	2.40	1.20	1.85	2.00	1.10	4.75	2.35	
7	3.30	2.60	7.15	3.15	2.15	1.10	1.65	1.85	1.00	4.50	2.25	
8	2.95	2.10	6.15	3.65	2.00	1.10	1.45	1.70	1.10	4.25	2.20	
9	2.55	1.90	6.55	5.30	2.00	1.10	1.40	1.60	1.10	3.95	2.05	
10	2.35	1.70	7.35	6.60	1.85	1.00	1.40	1.50	1.20	3.60	1.90	
11	2.25	1.50	7.70	6.60	1.50	1.00	1.35	2.55	1.25	3.30	1.80	
12	2.35	1.50	7.45	6.15	1.30	1.00	1.30	2.95	1.30	4.60	1.55	
13	2.30	1.40	7.30	5.80	1.30	1.05	1.20	3.60	1.40	5.05	1.45	
14	2.20	1.40	7.50	4.55	1.30	1.25	1.20	3.50	1.50	4.85	1.35	
15	2.05	1.30	7.15	4.05	1.20	1.30	1.20	3.50	1.50	4.65	1.30	
16	1.50	1.20	7.00	3.60	1.20	1.30	1.20	3.25	1.40	4.15	1.30	
17	1.60	1.20	5.90	3.40	1.20	1.30	1.10	3.05	1.15	3.65	1.30	
18	1.50	1.20	6.60	3.10	1.15	1.30	1.20	2.70	1.10	3.00	1.30	
19	1.45	1.10	5.55	2.60	1.10	1.25	1.30	2.55	1.10	3.00	1.3	
20	1.30	1.20	4.65	2.50	1.20	1.25	1.30	2.65	1.10	2.95	1.30	
21	1.80	1.30	4.35	2.50	1.20	1.35	1.35	2.45	1.10	2.80	1.30	
22	5.75	1.50	4.10	2.40	1.20	1.70	1.50	2.25	1.10	2.65	1.30	
23	7.75	1.70	3.75	2.40	1.10	1.65	1.45	2.15	1.00	2.40	1.00	
24	6.85	1.85	3.40	2.30	1.10	1.50	1.40	1.90	1.10	2.05	1.00	
25	5.45	2.45	3.15	2.20	1.20	1.50	1.75	1.60	1.25	1.85	1.30	
26	4.35	4.30	2.85	1.80	1.75	1.50	2.15	1.45	2.70	1.75	1.3	
27	4.30	7.20	2.60	1.65	2.15	1.65	2.20	1.20	3.30	1.65	1.45	
28	4.05	8.60	2.45	1.60	2.75	1.55	2.20	1.35	3.95	2.40	1.50	
29	3.45	.....	3.30	2.40	2.80	1.35	2.15	1.40	4.60	2.85	1.4	
30	3.15	.....	4.55	3.00	2.45	2.45	2.70	1.30	4.55	3.00	1.30	
31	3.20	.....	4.45	.....	2.25	.....	2.80	1.30	.....	3.90	.....	

Estimated monthly discharge of Pompton River at Two Bridges, New Jersey.

[Drainage area, 380 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	5,415	300	2,080	5.76	6.66
February	5,598	221	1,180	3.28	3.42
March	[a] 11,600	1,109	[a] 4,050	[a] 11.25	[a] 12.97
April	4,138	505	1,867	5.19	5.79
May	1,729	221	703	1.95	2.25
June	1,109	195	376	1.04	1.16
July	1,409	221	583	1.62	1.87
August	1,948	255	969	2.69	3.10
September	2,678	195	569	1.58	1.76
October	3,006	540	1,927	5.35	6.17
November	1,327	195	575	1.60	1.79
December	6,291	255	2,795	7.76	8.95
The year	[a] 11,600	195	1,473	4.09	55.89

[a] Estimated.

PASSAIC RIVER AT TWO BRIDGES, NEW JERSEY.

This station was established May 2, 1901, by George B. Hollister, ust above the confluence with Pompton River. Discharge measurements are made from a wagon bridge. The gage consists of a vertical pine board, marked in feet and tenths, spiked to the protecting imber on the upstream side of the first pier from the left bank. The ench mark is the top of the capstone of this pier, and its elevation s 13.65 feet above the datum of the gage. The channel is straight or some distance above and below the bridge. The bottom is gravelly. The right bank is about 10 feet high, while the left bank is ower and liable to overflow.

The flood of February–March, 1902, is considered the highest that has been recorded.

The following discharge measurements were made during 1902 by George B. Hollister:

January 17: Gage height, 2.30 feet; discharge, 398 second-feet.
March 1: Gage height, 13 feet; discharge, 8,096 second-feet.
May 20: Gage height, 3 feet; discharge, 622 second-feet.
June 18: Gage height, 2.30 feet; discharge, 328 second-feet.
September 11: Gage height, 2.30 feet; discharge, 354 second-feet.

Daily gage height, in feet, of Passaic River at Two Bridges, New Jersey.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	De
1902.												
1	9.50	3.70	11.55	5.25	4.40	3.10	3.30	3.75	2.30	5.55	3.75	
2	8.25	4.35	13.50	5.15	4.10	2.70	3.25	3.95	2.20	5.95	3.70	
3	7.45	4.50	12.80	4.65	3.80	2.40	3.00	3.55	2.15	5.70	3.65	
4	7.40	4.30	11.80	4.40	3.95	2.30	3.10	3.30	2.00	5.55	3.55	
5	7.05	4.15	10.75	4.15	3.55	2.20	3.00	3.10	2.00	5.45	3.35	
6	6.90	4.00	9.40	4.00	3.40	2.15	2.85	3.00	2.00	5.75	3.30	
7	4.50	3.80	8.15	4.15	3.15	2.10	2.65	2.85	2.00	5.50	3.30	
8	3.90	3.60	7.20	4.60	3.00	2.10	2.55	2.70	2.10	5.25	3.20	
9	3.50	3.40	7.50	6.25	3.00	2.10	2.40	2.60	2.10	4.95	3.05	
10	3.20	3.20	8.35	7.65	2.85	2.00	2.40	2.45	2.20	4.60	2.90	
11	3.00	3.20	8.70	7.65	2.50	2.00	2.35	3.50	2.25	4.30	2.80	
12	3.40	2.90	8.45	7.15	2.30	2.00	2.30	3.95	2.30	5.55	2.55	
13	3.25	2.60	8.30	6.70	2.30	2.20	2.20	4.60	2.40	6.05	2.45	
14	3.10	2.30	8.50	5.55	2.30	2.30	2.20	4.50	2.50	5.85	2.35	
15	2.80	2.10	8.15	5.10	2.30	2.30	2.20	4.50	2.50	5.65	2.30	
16	2.50	2.10	8.00	4.60	2.20	2.20	2.20	4.25	2.40	5.15	2.30	
17	2.50	2.10	6.90	4.40	2.20	2.30	2.10	4.05	2.15	5.65	2.30	
18	2.50	2.10	7.55	4.10	2.15	2.30	2.20	3.70	2.10	4.40	2.30	
19	2.45	2.20	6.75	3.40	2.10	2.25	2.25	3.55	2.10	4.00	2.30	
20	2.40	2.30	5.65	3.50	2.20	2.25	2.30	3.60	2.10	3.95	2.30	
21	2.00	2.45	5.35	3.50	2.20	2.40	2.35	3.35	2.10	3.80	2.30	
22	5.65	2.65	5.10	3.40	2.20	2.80	2.50	3.20	2.10	3.65	2.10	
23	8.80	2.70	4.75	3.40	2.10	2.75	2.45	3.05	2.00	3.40	2.00	
24	7.95	3.40	4.40	3.30	2.10	2.60	2.40	2.90	2.10	3.05	2.00	
25	6.80	3.90	4.15	3.20	2.25	2.60	2.75	2.60	2.25	2.85	2.30	
26	5.80	5.45	3.75	2.80	2.60	2.50	3.15	2.35	2.85	2.75	2.30	
27	5.70	8.15	3.50	2.65	2.95	2.65	3.20	2.20	3.60	2.65	2.45	
28	5.45	9.60	3.35	2.65	3.35	2.55	3.20	2.35	4.55	3.40	2.50	
29	4.75	.....	4.25	3.30	3.65	2.40	3.15	2.40	5.60	3.60	2.40	
30	4.40	.....	5.55	3.90	3.45	3.80	3.70	2.30	5.55	4.00	2.30	
31	3.80	.....	5.35	.....	3.25	.....	3.85	2.20	.....	3.90	.....	

Estimated monthly discharge of Passaic River at Two Bridges, New Jersey.

[Drainage area, 360 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches
1902.					
January	3,832	225	1,616	4.49	5.1
February	4,011	271	1,003	2.79	2.9
March	[a] 11,600	863	[a] 2,863	[a] 7.95	[a] 9.1
April	3,016	527	1,424	3.96	4.4
May	1,375	271	618	1.72	1.9
June	839	225	408	1.13	1.3
July	1,103	271	550	1.53	1.7
August	1,475	317	808	2.24	2.5
September	1,975	225	488	1.36	1.5
October	2,200	527	1,467	4.08	4.7
November	1,055	225	534	1.48	1.6
December	4,496	317	2,071	5.75	6.6
The year	[a] 11,600	225	1,154	3.21	43.7

[a] Estimated.

MISCELLANEOUS NEW JERSEY STREAMS.

The following discharge measurements were made on streams in ew Jersey:

Miscellaneous discharge measurements made on New Jersey streams.

Date.	Stream.	Locality.	Discharge.
1902.			*Sec.-ft.*
ly 1	Paulinskill	Warrington, N. J	1,390
ıgust 31	do	Columbia, N. J	98
ne 26	Ramapo	Mahwah, N. J	123
tober 29	do	do	678
ptember 24	Rockaway	Old Boonton, N. J	33
ıgust 23	do	do	146
ptember 11	do	do	164
ptember 23	do	do	102
tober 30	do	do	488
tober 30	Pompton	Pompton Plains, N. J	1,066
ptember 26	Passaic	Stanley, N. J	195
tober 30	do	do	431
ptember 26	do	Millington, N. J	92
ugust 28	Whippany	Whippany, N. J	35
ıly 1	North Branch Raritan	Far Hills, N. J	35
ugust 29	do	do	41
eptember 26	do	Pluckemin, N. J	171
eptember 19	Raritan	Bound Brook, N. J	323
eptember 20	do	do	427
lovember 6	do	do	947
eptember 24	South Branch Raritan	German Valley, N. J	58
eptember 24	do	Califon, N. J	51
eptember 25	do	Neshanic, N. J	172
eptember	do	High Bridge, N. J	120
uly 1	Lamington	Pottersville, N. J	545
ugust 29	do	do	32
eptember 23	Pequannock	Pompton, N. J	90
ugust 22	Wanaque	do	97

DELAWARE RIVER DRAINAGE BASIN.

Gaging stations are maintained in this basin by the United States Geological Survey on the West Branch of the Delaware at Hancock, N. Y.; on the East Branch of the Delaware at Hancock, N. Y.; on the Delaware River at Port Jervis, N. Y., and at Lambertville, N. J.; on the Neversink River at Port Jervis, N. J.; and on the Lehigh

River at South Bethlehem, Pa. Aside from these stations measurements have been made for several years by John E. Codman, hydrographer of the water department of the city of Philadelphia. The stations maintained by Mr. Codman are located on the following streams, all in the vicinity of Philadelphia: Perkiomen, Wissahickon, Tohickon, and Neshaminy creeks, and on the Schuylkill River. The following pages give the records of these stations for 1902.

WEST BRANCH OF DELAWARE RIVER AT HANCOCK, N. Y.

The Delaware River rises on the slope of Mine Mountain, near the southwestern line of Schoharie County, flows southwesterly across central Delaware County to Deposit, where it is joined by Oquaga Creek, a large tributary draining eastern Broome County. The upper drainage area is relatively long and narrow, with numerous short lateral tributaries. It is rugged and to a considerable extent wooded. There are low water-power dams near Hamden and Delhi. At Deposit the stream turns abruptly to the southeast, forming the boundary line between New York and Pennsylvania, until Port Jervis is reached. Here it encounters the foot of the Shawangunk Range, and its direction of flow is again turned to the southwest. Below Port Jervis the Delaware forms the division between Pennsylvania and New Jersey and ultimately empties into Delaware Bay below Philadelphia. Above Hancock the main stream is known as the West Branch of Delaware River,[a] to distinguish it from the smaller East or Pepacton Branch of Delaware River.

The gaging station on West Branch of Delaware River is situated at the suspension bridge in Hancock village. A 15-foot weight and wire gage, reading decimally, is attached to the upstream side of the bridge. The stream bed is of rock, overlain with gravel and cobblestone.

The bench mark is a circular chisel draft on the upstream corner of the left abutment. Elevation of bench mark is 100 feet. Elevation of water surface when gage reads zero is 75.75. The gage was erected October 15, 1902, by P. M. Churchill and C. C. Covert.

The gage is read each day at 8 a. m. and again at 4 p. m. by David Pulver, collector of tolls at the bridge.

The gaging station is situated approximately one-half mile upstream from the junction of the East and West branches of the stream. The bridge has a span between abutments of 235 feet. The bridge is spaced in 5-foot intervals on the downstream side, beginning at face of left abutment. Discharge measurements are made from the lower side of the bridge.

A discharge measurement by P. M. Churchill and C. C. Covert, hydrographers, October 15, 1902, showed a discharge of 1,123 second-feet, gage height 3.95 feet.

[a] Sometimes called Mohawk. It should not be confused with the Mohawk River, a tributary of Hudson River.

an daily gage height, in feet, of West Branch of Dela: are River at Hancock, N. Y.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.				1902.			
		4.55	3.00	12		3.30	3.70	23	3.18	2.65	6.90
		4.33	2.98	13		3.20	3.85	24	3.18	2.80	5.50
		4.33	3.35	14		3.20	3.80	25	3.20	2.73	5.23
		4.43	3.30	15	3.90	3.07	3.90	26	3.00	2.90	4.72
		3.75	3.25	16	3.60	2.97	5.25	27	3.15	3.15	4.55
		3.75	3.25	17	3.40	2.87	7.47	28	7.03	3.13	4.35
		3.53	3.25	18	3.40	2.87	6.23	29	6.83	3.05	4.05
		3.35	3.28	19	3.47	2.85	5.40	30	5.57	2.93	4.25
		3.32	3.08	20	3.50	2.80	5.18	31	5.00		4.00
		3.25	3.20	21	3.43	2.82	4.93				
		3.15	3.75	22	3.35	2.85	8.43				

EAST BRANCH OF DELAWARE RIVER AT HANCOCK, N. Y.

East Branch of Delaware River flows parallel to the West Branch ;ross southern Delaware County. The drainage area is broader ıd the tributaries longer and more branching than those of the West ranch. Many of the tributaries head in small lakes and ponds.

The gaging station is situated at the highway bridge in Hancock illage. A 15-foot weight and wire gage, graduated decimally, is ttached to the horizontal chords of the upstream side of the second pan from the left or south abutment. The reference point is a cir-ular chisel draft on the downstream corner of the left abutment. ts elevation referred to the bench mark described above in connec-ion with the station on the West Branch of the stream is 98.52.

The elevation of the datum plane of the gage or of water surface ;hen the gage reads zero is 70.59, or 5.16 feet lower than that for the Vest Branch station.

The bridge consists of five spans and has a length between abut-nents of 425.5 feet. Discharge measurements are usually made from he downstream side. Bridge is marked off in 5-foot spaces, beginning ıt right abutment.

During low water the elevation of water in the East Branch is lower ;han that in the West Branch at the respective gaging stations. There is considerable fall in each branch from the gaging station to ;he mouth of the stream.

The gage was erected October 14, 1902, by P. M. Churchill and C. C. Covert. The gage is read twice daily, at 8 a. m. and 4 p. m., by D. B. Van Etten. A discharge measurement made by Messrs. Churchill and Covert October 14, 1902, with a gage height of 4.345 feet, showed a discharge of 2,320 second-feet.

The drainage area tributary to each branch between the gaging station and the mouth of the stream is approximately 1 square mile.

The location of the two gaging stations close to the mouths of the

branches enables the total discharge of the main stream at the confluence of its principal branches to be determined.

The highest recent freshet on the East Branch occurred December 15–16, 1901. The elevation of water surface was 93.02 feet, equivalent to a gage reading of 22.43 feet.

Mean daily gage height, in feet, of East Branch of Delaware River at Hancock, N. Y.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.				1902.			
1		4.85	3.40	12		3.60	5.55	23	3.60	3.50	
2		4.55	3.40	13		3.60	5.60	24	3.50	3.40	
3		4.40	3.50	14		3.50	5.85	25	3.50	3.50	
4		4.25	3.70	15	4.20	3.40	5.95	26	3.40	3.35	
5		4.10	3.70	16	4.10	3.40	6.50	27	3.40	3.45	
6		4.00	3.50	17	4.00	3.40	8.65	28	6.25	3.40	
7		3.95	3.50	18	3.90	3.30	6.35	29	7.05	3.55	
8		3.80	3.70	19	3.80	3.30	5.50	30	5.75	3.50	
9		3.70	5.75	20	3.80	3.30	5.00	31	5.40		
10		3.60	5.60	21	3.75	3.20	4.80				
11		3.60	5.90	22	3.60	3.20	10.00				

DELAWARE RIVER AT PORT JERVIS, N. Y.

From Hancock to Port Jervis, a distance by river of 76 miles, the Delaware flows in a broad, shallow channel, with numerous small rifts and a relatively rapid current. Several large tributaries enter in this section of the stream, notably Mongaup and Callicoon creeks and Neversink River from the New York side, and the Lackawaxen River from Pennsylvania.[a]

The following table shows the drainage areas of the Upper Delaware River and its principal tributaries:

Drainage area of Upper Delaware River and principal tributaries.

	Square miles
Delaware River at mouth	10,000
Delaware River at Lambertville, N. J.[b]	6,780
Delaware River at Port Jervis, below mouth of Neversink River	3,070
Delaware River at Port Jervis, above mouth of Neversink River	2,900
Neversink River at mouth	170
Lackawaxen River at mouth	320
Mongaup Creek at mouth	240
Delaware River below junction of branches at Hancock, N. Y.	1,530
West Branch of Delaware River above mouth at Hancock, N. Y.	1,210
West Branch of Delaware River above Oquaga Creek at Deposit, N. Y.	1,000
West Branch of Delaware River at Walton, N. Y.	780
East Branch of Delaware River at mouth, Hancock, N. Y.	810

[a] For general description and drainage areas of Delaware River see Tenth United States census, Volume XVI, pp. 607–638.

[b] Results are given in Water Supply and Irrigation Paper United States Geological Survey No. 65, p. 214.

The drainage area of Delaware River above Port Jervis lies about four-fifths in New York and one-fifth in Pennsylvania.

Arrangements have been made for the establishment of a gaging station at the upper railroad bridge in Port Jervis. The bridge is situated about 1 mile upstream from the mouth of Neversink River. The bridge consists of two spans and stands squarely across the stream. The current is smooth and uniform. The stream bed is cobblestone and gravel, and fairly permanent.

The following discharge measurements have been made by George S. Hollister, resident hydrographer for New Jersey, at the Barrett suspension toll bridge:

June 28: Gage height, 29.3 feet; discharge, 4,629 second-feet.
September 2: Gage height, 30.6 feet; discharge, 1,501 second-feet.

The gage height as given is the distance down to water surface from a reference point on top of upstream guard rail 470 feet from the left-hand abutment.

NEVERSINK RIVER AT PORT JERVIS, N. Y.

Neversink River rises in southwestern Ulster County. Two branches unite to form the main stream near Sullivan County line. The stream then flows southerly, crossing eastern Sullivan County, and enters Delaware River at Port Jervis.

The drainage basin contains numerous small lakes. The fall is rapid and often precipitous. This stream has been suggested as a possible source of water supply for New York, the proposed point of diversion being "The Kitchen," at Quarryville, at an elevation of 850 feet above tide. The drainage area at this point is 200 square miles and at the mouth of the stream 346 square miles.[a]

The gaging station is situated at the East Main street highway bridge in Port Jervis.[b] A wire-and-weight gage is secured to the iron-work of the bridge on the downstream side. The bench mark is an anchor bolt in top of cemetery wall on right bank of stream; its elevation is taken at 100 feet. The datum plane of the gage referred to this bench mark is 72.24. The station was established October 16, 1902, by P. M. Churchill and C. C. Covert. The gage record is kept by Edwin J. Earley. Readings are taken at 8.30 a. m. and 5 p. m. each day.

The bridge has a single span of 130 feet between abutments. The stream flows between entraining walls and has a rock bed overlain in part by earth. The discharge measurements are usually made from the upstream side of the bridge, which has been divided into 5-foot stations, beginning at the right-hand abutment.

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[a] See Freeman's report on New York water supply, 1900, p. 491.
[b] Temporary.

Discharge measurements of Neversink River at Port Jervis, N. Y.

Date.	Gage height.	Discharge.	Hydrographer.
1902.	*Feet.*	*Second-feet.*	
October 16	7.45	945	Churchill and Covert.
November 10	7.00	524	F. H. Tillinghast.

Two discharge measurements were made before the gage was placed by George B. Hollister:

	Second-feet.
June 28, 1902	54
September 17, 1902	15

Mean daily gage height, in feet, of Neversink River at Port Jervis, N. Y.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1902.				1902.				1902.			
1	.....	7.60	6.90	12	.....	7.00	6.90	23	7.05	6.80	[illegible]
2	.....	7.40	6.90	13	.....	7.00	6.90	24	7.03	6.80	[illegible]
3	.....	7.25	7.10	14	.....	6.90	6.90	25	7.00	6.80	[illegible]
4	.....	7.20	7.20	15	.....	6.90	6.85	26	6.95	6.80	[illegible]
5	.....	7.20	7.00	16	7.50	6.90	6.95	27	6.90	6.90	[illegible]
6	.....	7.15	7.00	17	7.40	6.90	11.75	28	8.75	7.00	[illegible]
7	.....	7.15	7.00	18	7.30	6.90	9.11	29	10.05	7.00	[illegible]
8	.....	7.10	6.90	19	7.30	6.80	9.50	30	8.85	6.90	[illegible]
9	.....	7.00	6.70	20	7.20	.....	9.05	31	7.95	.....	[illegible]
10	.....	7.00	6.70	21	7.10	.....	8.45				
11	.....	7.00	6.90	22	7.08	.....	13.10				

LEHIGH RIVER AT SOUTH BETHLEHEM, PA.

This station was established December 22, 1902, on the New street bridge, and is under the general supervision of Prof. Mansfield Merriman, C. E., of Lehigh University. The equipment consists of a standard chain-and-weight gage, which is referred to a horizontal scale board graduated to feet and tenths, inclosed in a lock box attached to the lower side of the bridge. The length of the chain from the zero to the extreme end of the weight is 43.77 feet. The datum of the gage is 210.55 feet above sea level, and is referred to the Lehigh Valley Railroad bench mark No. 72, which is an iron pin in the south pier of the New street bridge. Its elevation is 232.87 feet above sea level.

The following discharge measurements were made during 1902:

September 22: Gage height, 2.3 feet; discharge, 1,171 second-feet.
November 14: Gage height, 2.8 feet; discharge, 1,696 second-feet.
November 20: Gage height, 2.6 feet; discharge, 1,436 second-feet.

Daily gage height, in feet, of Lehigh River at New street bridge, South Bethlehem, Pa.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1902.					1902.					1902.				
.....	.....	6.10	3.75	2.60	12.....	.....	5.67	2.85	2.70	23.....	2.20	3.20	2.60	8.35
.....	.....	6.10	3.65	2.60	13.....	.....	5.85	2.80	2.75	24.....	2.17	3.05	2.60	6.45
.....	.....	5.80	3.50	2.90	14.....	.....	5.05	2.80	2.80	25.....	2.80	3.80	2.60	5.65
.....	.....	4.75	3.40	3.00	15.....	.....	4.55	2.80	2.80	26.....	8.45	3.00	2.60	5.10
.....	.....	4.65	3.30	3.00	16.....	.....	4.25	2.70	4.40	27.....	8.10	2.95	2.60	4.70
.....	.....	5.55	3.40	3.00	17.....	.....	3.95	2.75	8.70	28.....	6.20	5.25	2.60	4.30
.....	.....	5.05	3.35	3.00	18.....	.....	3.80	2.65	6.00	29.....	5.85	4.90	2.60	4.10
.....	.....	4.60	3.20	3.00	19.....	.....	3.75	2.65	5.10	30.....	5.70	4.40	2.60	4.00
.....	.....	4.40	3.05	2.55	20.....	.....	3.65	2.60	4.60	31.....	.....	4.00	.....	3.90
.....	.....	4.00	2.95	2.55	21.....	.....	3.40	2.60	4.90					
.....	.....	3.75	2.90	2.60	22.....	2.30	3.25	2.60	12.30					

DELAWARE RIVER AT LAMBERTVILLE, N. J.

This river rises in Delaware County, N. Y., flows in a southerly irection, forming the boundary between the States of Pennsylvania nd New Jersey, and empties into Delaware Bay. Measurements of low were made during the latter half of June, 1891, by Prof. Dwight 'orter and students at the Delaware Watergap, Pa. The results show , flow of from 2,000 to 2,200 second-feet. This was said to be the lowest une stage for five years. Measurements were made during the lrought of 1895 by Prof L. M. Haupt at Point Pleasant, Pa., near the ntake of the Delaware and Raritan Canal feeder. The discharge ibove the bridge was 1,657 second-feet and below the bridge 1,328 econd-feet. Delaware River was measured by E. G. Paul, June 4, .899, at Martins Creek, Pa., 7 miles above the mouth of Lehigh River, ind a discharge of 2,724 second-feet was found. Systematic measurements of river height were begun on July 23, 1897, at the covered oll bridge at Lambertville, N. J., a town on the Belvidere division of the Pennsylvania Railroad, 16 miles above Trenton. The gage, established by E. G. Paul, consists of a stamped-link brass chain with a 6-pound sash weight attached. The chain passes over a pulley and the index is referred to a scale painted on a horizontal board 32 feet long, fastened to the studding and inclosed in a wooden cover. The zero of the gage chain is marked by a copper rivet, which is 28.85 feet from the end of the weight, and reads 2 feet when the water is at zero on a gage on the first bridge pier. Measurements are made from the windows of this covered bridge. The initial point for soundings is on the left bank. The channel above and below is nearly straight, the water being sluggish for a short space on the left side. The right bank is high and and the bed of the stream is of gravel and sand. The observer is Charles H. Naylor, collector of bridge tolls, Lambertville, N. J.

The following discharge measurements were made during 1902 by E. G. Paul:

April 15: Gage height, 6.3 feet; discharge, including canal, 30,549 second-feet; discharge of canal, 513 second-feet.

September 23: Gage height, 2.9 feet; discharge measurement, including canal, 3,985 second-feet; discharge of canal, 517 second-feet.

Daily gage height, in feet, of Delaware River at Lambertville, N. J.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	7.40	(a)	18.17	7.05	5.80	3.70	6.10	5.45	3.30	10.55	6.15	[illegible]
2	6.45	4.75	20.21	6.60	5.85	3.55	6.05	5.20	3.20	9.60	5.75	[illegible]
3	5.80	4.90	16.40	6.25	5.40	3.45	5.50	5.95	3.10	8.60	5.40	[illegible]
4	5.40	(a)	12.50	5.95	5.20	3.40	5.15	5.70	2.95	7.40	5.10	[illegible]
5	5.00	.....	9.45	5.65	5.15	3.30	5.75	5.15	2.90	6.90	5.00	[illegible]
6	4.95	.....	8.15	5.45	5.00	3.80	5.20	4.85	2.85	7.10	4.85	[illegible]
7	4.90	.....	6.80	5.60	4.70	3.55	5.00	4.70	2.70	6.65	4.75	[illegible]
8	4.85	.....	6.45	6.05	4.65	3.55	5.10	4.50	2.80	6.25	4.65	[illegible]
9	4.70	.....	7.00	7.20	4.50	3.40	5.10	4.35	2.90	5.80	4.55	[illegible]
10	4.70	.....	7.70	8.05	4.30	3.35	4.70	4.20	3.45	5.45	4.40	[illegible]
11	4.50	.....	7.95	8.30	4.20	3.30	4.50	4.15	3.65	5.20	4.30	[illegible]
12	4.45	.....	7.60	7.55	4.10	3.40	4.25	4.20	4.10	6.70	4.20	[illegible]
13	4.15	.....	8.85	7.10	4.10	3.45	4.15	4.10	3.95	7.15	4.10	[illegible]
14	(a)	.....	11.05	6.75	4.00	3.65	4.00	3.90	3.70	6.90	4.10	[illegible]
15	.....	.....	10.20	6.25	3.90	3.65	3.80	3.80	3.55	6.30	4.00	[illegible]
16	.....	.....	8.70	5.95	3.90	3.55	3.65	3.70	3.45	5.90	3.95	[illegible]
17	.....	.....	9.35	5.60	3.80	3.55	3.60	3.60	3.25	5.55	4.00	[illegible]
18	.....	.....	11.80	5.45	3.75	3.75	3.50	3.50	3.20	5.25	3.85	[illegible]
19	.....	.....	9.70	5.15	3.75	3.85	3.50	3.30	3.00	5.10	3.80	[illegible]
20	3.90	.....	7.90	5.10	3.65	3.80	3.65	3.45	2.95	4.95	3.80	[illegible]
21	3.80	.....	7.20	4.90	3.70	3.75	3.95	3.30	2.95	4.75	3.70	[illegible]
22	8.93	.....	6.75	4.80	3.65	4.85	6.10	3.50	3.10	4.60	3.70	[illegible]
23	8.55	.....	6.35	4.65	3.60	4.30	6.35	3.35	3.00	4.50	3.75	[illegible]
24	7.95	.....	6.20	4.55	3.55	4.15	5.75	3.40	2.85	4.40	3.70	[illegible]
25	6.60	.....	6.10	4.45	3.50	3.85	5.55	3.30	2.90	4.30	3.70	[illegible]
26	5.80	8.90	5.90	4.30	3.50	3.85	5.90	3.20	5.65	4.25	3.85	[illegible]
27	5.70	8.66	5.70	4.30	3.95	4.00	5.45	3.00	9.70	4.20	4.10	[illegible]
28	5.75	12.34	5.45	4.30	4.05	3.95	4.90	2.95	9.05	4.20	4.10	[illegible]
29	5.45	.....	5.80	4.20	4.10	4.00	4.80	3.15	8.35	7.20	4.20	[illegible]
30	(a)	.....	7.60	5.15	3.90	4.70	5.20	3.10	12.10	8.20	4.15	[illegible]
31	.....	.....	7.90	.....	3.85	.....	5.60	3.30	.....	6.95	.....	[illegible]

a Frozen January 14 to 19, January 30 to February 1, and February 4 to 25.

Rating table for Delaware River at Lambertville, N. J., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.4	1,750	4.0	8,550	5.6	22,150	7.2	37,810
2.6	2,100	4.2	10,000	5.8	24,050	7.4	39,870
2.8	2,600	4.4	11,650	6.0	25,950	7.6	41,930
3.0	3,300	4.6	13,350	6.2	27,850	7.8	43,990
3.2	4,100	4.8	15,050	6.4	29,750	8.0	46,050
3.4	5,050	5.0	16,750	6.6	31,700	8.5	51,200
3.6	6,100	5.2	18,500	6.8	33,710	9.0	56,350
3.8	7,250	5.4	20,300	7.0	35,750	9.5	61,500

Estimated monthly discharge of Delaware River at Lambertville, N. J.

[Drainage area, 6,855 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January [a]	----------	----------	[b] 20,017	[b] 2.92	[b] 3.37
February [a]	----------	----------	----------	----------	----------
March	171,813	20,750	55,811	8.14	9.38
April	49,140	10,000	24,039	3.51	3.92
May	24,525	5,550	10,701	1.56	1.80
June	14,200	4,550	6,848	1.00	1.12
July	26,900	5,550	16,352	2.39	2.76
August	25,475	3,125	9,310	1.36	1.41
September	88,280	2,300	12,922	1.89	2.11
October	72,315	10,000	28,250	4.12	4.75
November	27,375	6,650	11,323	1.65	1.84
December	96,520	8,550	29,351	4.28	4.93

[a] Frozen January 14 to 19, January 30 to February 1, and February 4 to 25. [b] Estimated.

PERKIOMEN CREEK AT FREDERICK, PA.

Perkiomen Creek drains an area lying northwest of the city of Philadelphia. It flows in a southerly direction, emptying into Schuylkill River about 7 miles above Norristown and about 18 miles above Philadelphia. The point of measurement of discharge is located at Frederick, this being about 12 miles above the mouth. This point is also above two large tributaries known as West Swamp Creek and

Northeast Branch of Perkiomen. Both of these tributaries have been measured—the first at Zieglerville, and the second near Schwenksville. The drainage area of the Perkiomen above the point of measurement is given by Rudolph Hering as 152 square miles, of which 111 are cultivated and improved and 41 untillable and wooded. Measurements of this creek were begun on August 20, 1884. Water-Supply Paper No. 35 contains tables of the daily discharge for the entire period from 1884 to 1899, inclusive. The records of daily discharge for 1902, as furnished by John E. Codman, hydrographer of the water department of Philadelphia, are given in the following table:

Daily discharge, in second-feet, of Perkiomen Creek at Frederick, Pa.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	269	119	2,657	246	253	47	226	69	51	87	128	72
2	249	228	1,598	199	196	45	124	68	39	304	117	88
3	193	375	708	157	194	51	79	58	38	215	113	179
4	168	307	400	142	191	51	102	45	31	158	109	49
5	148	236	284	133	162	45	107	45	26	396	104	34
6	114	168	315	270	140	45	67	45	26	1,185	102	27
7	111	121	301	345	123	45	59	51	26	358	107	24
8	111	75	284	1,638	109	45	54	49	26	228	101	23
9	111	75	1,443	1,564	96	45	51	43	77	158	93	20
10	111	75	2,840	738	88	45	43	43	171	119	67	18
11	101	66	1,753	426	79	45	43	49	69	380	51	18
12	92	51	835	301	74	45	45	212	38	2,350	71	17
13	92	45	828	238	75	45	43	114	31	522	75	15
14	83	45	497	188	79	56	38	50	28	286	75	13
15	66	45	352	166	79	67	35	49	29	219	73	12
16	58	45	323	154	73	71	35	37	28	193	72	159
17	51	45	972	150	61	83	49	24	26	165	89	74
18	45	45	406	143	53	79	43	30	28	140	104	73
19	45	45	273	134	57	67	40	33	28	133	92	69
20	45	45	235	119	66	62	75	34	26	123	84	67
21	1,084	137	219	114	69	61	82	38	26	110	79	65
22	5,259	1,798	198	118	67	103	113	39	26	101	85	100
23	388	800	178	112	64	66	66	32	28	99	86	87
24	221	485	163	105	56	54	53	20	30	95	79	82
25	160	1,104	143	100	59	54	113	18	44	89	106	76
26	142	6,035	123	95	65	227	150	30	1,379	78	434	74
27	688	2,569	118	88	77	143	73	38	1,684	71	430	82
28	238	6,843	123	86	96	101	58	254	360	1,045	295	97
29	194	.....	944	159	84	68	58	324	313	428	198	79
30	168	.....	765	581	61	175	58	101	186	260	147	57
31	139	.....	341	.....	51	.....	66	69	.....	163	.....	73

Estimated monthly discharge of Perkiomen Creek at Frederick, Pa.

[Drainage area, 152 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
nuary	5,259	45	353	2.32	2.67
bruary	6,843	45	787	5.18	5.39
arch	2,840	118	665	4.38	5.05
pril	1,638	86	300	1.97	2.20
ay	253	51	97	.64	.74
ne	227	45	71	.47	.52
ly	226	35	72	.47	.54
ugust	324	18	68	.45	.52
ptember	1,684	26	164	1.08	1.20
ctober	2,350	71	366	2.41	2.78
ovember	438	46	123	.81	.90
ecember	5,011	172	850	5.59	6.44
The year	6,843	18	326	2.15	28.95

WISSAHICKON CREEK NEAR PHILADELPHIA, PA.

The drainage basin of this creek is immediately adjacent to Philadelphia, and between Little Neshaminy and Perkiomen creeks. It flows through Fairmount Park, emptying into the Schuylkill River about 12 miles from its mouth. Measurements of flow were begun in April, 1897, under the direction of John E. Codman, at a point about 100 yards above the junction of the creek with Schuylkill River. June 5, 1899, the observations were discontinued temporarily, and were not again resumed until July 1, 1900. The figures for monthly flow for 1899 and diagrams of daily discharge for the entire period of observation (1897 to 1899, inclusive) will be found in the Twenty-first Annual Report, Part IV, pages 81 and 82. The following figures for 1902 were furnished by Mr. Codman.

Daily discharge, in second-feet, of Wissahickon Creek near Philadelphia, Pa

Day.	Jan.	Feb.	Mar	Apr.	May
1902.					
1	163	22	1,967	114	
2	158	146	870	106	
3	112	162	485	102	
4	99	138	198	102	
5	93	49	104	106	
6	77	22	119	106	
7	63	22	148	106	
8	45	22	184	690	
9	42	22	247	415	
10	44	22	367	183	
11	32	22	255	161	
12	31	22	255	157	
13	31	22	247	140	
14	31	22	227	122	
15	31	22	195	106	
16	31	22	168	106	
17	27	22	155	114	
18	22	22	118	114	
19	22	22	104	106	
20	22	22	143	106	
21	151	22	161	98	
22	1,093	398	148	91	
23	101	557	140	91	
24	84	270	141	89	
25	68	334	141	84	
26	77	1,511	131	82	
27	171	1,821	123	72	
28	124	1,983	124	72	
29	26	----------	127	111	
30	25	----------	207	108	
31	24	----------	128	----------	

[a] Water drained out of pond for repairs.

TOHICKON CREEK AT POINT PLEASANT, PA.

Tohickon Creek drains an area of 102 square miles in Bucks County, north of Philadelphia. It flows in an easterly course, entering Delaware River about 8 miles above Lambertville, N. J. In a statement by Rudolph Hering, printed in the report of the Philadelphia water department for 1885, on page 350, is given a classification of the drainage area of Tohickon Creek, from which it appears that 76 square miles is cultivated and improved and 26 square miles untillable and wooded. Measurements of the discharge of the creek are made near its mouth at Point Pleasant. Rain gages are located within the drainage basin at Quakertown, also at a point about 3 miles north of Bedminster, and near Point Pleasant.

Tables of daily discharge in second-feet, for the years 1883 to 1899 inclusive, are published in Water-Supply Paper No. 47, page 51. Daily records of gage height were not kept during 1900. The following figures of discharge for 1902 were furnished by Mr. Codman.

Daily discharge, in second-feet, of Tohickon Creek at Point Pleasant, Pa.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	339	206	5,958	142	166	10	69	18	3	363	64	107
	201	357	551	112	65	7	51	20	2	351	55	136
	135	584	460	78	65	7	40	20	4	214	51	1,359
	87	708	348	58	73	5	34	12	4	114	48	430
	87	528	175	50	61	5	26	16	3	1,227	45	274
	87	266	185	96	47	3	21	13	3	1,500	41	215
	87	184	212	297	35	3	19	17	2	490	41	148
	79	157	153	1,523	31	4	19	12	2	162	39	124
	71	109	1,089	1,772	27	5	16	7	13	92	94	107
	71	102	1,977	589	23	6	9	6	6	68	94	107
	71	102	1,280	286	20	5	11	12	8	612	32	68
	71	79	775	133	22	3	13	37	6	2,616	30	102
	64	71	741	96	22	4	6	37	6	909	31	108
	58	71	539	83	18	10	8	27	6	227	29	119
	53	55	246	67	17	10	9	17	4	119	32	119
	48	34	291	56	17	8	9	15	7	87	30	2,505
	48	26	1,197	48	17	12	9	14	6	70	26	3,367
	43	23	488	45	12	12	5	12	5	57	26	1,024
	39	17	159	43	15	10	3	17	6	50	23	444
	39	10	110	38	20	9	4	15	5	48	22	429
	614	34	98	35	12	7	7	11	4	48	21	1,999
	2,969	710	88	34	9	13	33	11	4	41	22	4,260
	407	675	80	31	9	6	26	12	5	36	88	1,854
	124	642	72	27	9	8	260	8	5	39	92	353
	82	582	60	20	7	9	515	8	7	34	31	147
	59	3,406	49	16	7	19	180	8	1,129	26	337	54
	300	2,419	48	16	10	24	81	4	2,291	23	435	75
	114	5,216	85	20	12	23	44	4	1,536	1,304	189	84
	131	.....	996	23	14	45	39	4	734	526	94	205
	102	.....	772	251	9	110	37	3	830	189	71	337
	137	.....	226	.....	12	.....	23	3	.....	97	.....	157

Estimated monthly discharge of Tohickon Creek at Point Pleasant, Pa.

[Drainage area, 102 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
anuary	2,969	39	220	2.16	2.49
ebruary	3,406	10	620	6.08	6.33
[arch	5,958	48	629	6.17	7.11
pril	1,772	16	203	1.99	2.22
[ay	166	7	28	.27	.31
une	110	3	13	.13	.15
ıly	515	3	52	.51	.59
ugust	37	3	14	.14	.16
eptember	2,291	2	222	2.18	2.43
ctober	2,616	23	377	3.70	4.27
Tovember	435	21	74	.73	.81
)ecember	4,260	54	671	6.58	7.59
The year	5,958	2	260	2.55	34.46

NESHAMINY CREEK, PENNSYLVANIA, BELOW THE FORKS.

The drainage basin of Neshaminy Creek is immediately south of that of Tohickon Creek and of a portion of that of Perkiomen Creek. The stream flows in a general southeasterly and southerly course, entering Delaware River at a point about 12 miles above Philadelphia. The point of measurement is at the forks of Big and Little Neshaminy creeks. The drainage area at this point is 139.3 square miles, of which 128.2 are cultivated and improved and 11.1 miles untillable and wooded. The daily discharges from 1884 to 1900 are given in Water-Supply Paper No. 47, pages 90 to 98. The following table of daily discharge for 1902 was furnished by Mr. Codman:

Daily discharge, in second-feet, of Neshaminy Creek below the forks, Pennsylvania.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	224	228	2,553	190	129	22	103	52	24	2,375	135	[illegible]
2	318	551	1,414	148	84	22	61	32	23	474	125	[illegible]
3	223	753	619	121	93	19	41	87	17	257	115	[illegible]
4	144	540	264	114	63	17	36	358	16	194	105	[illegible]
5	144	474	225	114	81	17	31	42	16	1,787	105	[illegible]
6	144	381	176	145	70	18	28	72	15	2,053	105	[illegible]
7	144	176	229	248	57	20	28	80	15	379	105	[illegible]
8	134	154	243	2,009	59	22	26	44	16	257	100	[illegible]
9	125	144	2,597	1,510	56	18	18	38	53	208	95	[illegible]
10	125	144	2,272	562	39	18	16	409	61	173	87	[illegible]
11	115	134	1,682	380	31	18	18	729	35	659	77	[illegible]
12	105	125	751	272	31	16	22	388	26	3,497	72	[illegible]
13	105	125	502	221	36	20	19	153	16	591	71	[illegible]
14	96	125	621	200	31	18	15	86	15	337	67	[illegible]
15	88	115	501	182	26	15	22	70	16	258	66	[illegible]
16	88	105	309	154	26	25	24	55	16	218	63	[illegible]
17	88	105	1,283	144	26	33	20	49	15	194	59	[illegible]
18	88	105	445	134	23	26	16	49	14	181	48	[illegible]
19	88	105	235	125	21	20	16	39	14	169	42	[illegible]
20	80	105	186	113	26	16	15	37	15	152	50	[illegible]
21	619	329	179	99	31	308	12	40	15	137	50	[illegible]
22	3,226	3,043	175	93	31	157	13	34	15	125	51	[illegible]
23	352	1,495	154	81	31	49	15	30	15	115	48	[illegible]
24	183	604	144	72	31	36	481	36	13	110	32	[illegible]
25	139	353	124	72	68	36	758	41	42	105	91	[illegible]
26	134	6,063	115	73	70	175	168	36	1,399	102	55	[illegible]
27	601	3,438	125	64	49	79	55	95	1,249	107	92	[illegible]
28	368	4,041	153	60	55	30	31	100	379	1,195	146	[illegible]
29	188	.....	448	95	48	312	45	33	440	330	104	[illegible]
30	164	.....	679	206	37	269	65	28	174	182	113	[illegible]
31	154	.....	450	.....	24	.....	71	26	.....	150	.....	[illegible]

imated monthly discharge of Neshaminy Creek below the forks, Pennsylvania.

[Drainage area, 139 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
uary	3,226	80	284	2.04	2.35
ruary	6,063	105	877	6.31	6.57
rch	2,597	115	640	4.60	5.30
ril	2,009	60	267	1.92	2.14
y	129	21	49	.35	.40
ne	312	15	62	.45	.50
ly	758	12	74	.53	.61
gust	729	26	108	.78	.90
ptember	1,399	13	139	1.00	1.12
tober	3,497	102	550	3.96	4.57
vember	282	42	95	.68	.76
cember	3,174	140	676	4.86	5.60
The year	6,063	12	318	2.29	30.82

SCHUYLKILL RIVER NEAR PHILADELPHIA, PA.

This river receives the drainage of the portion of southeastern ennsylvania lying between the Lehigh River on the north and the isquehanna River on the south. It flows in a general southeasterly ourse, emptying into Delaware River, the city of Philadelphia being cated at the junction of these streams. Records of the height of ie river at Fairmount pool have been kept for many years, but not i such form as to be useful in computing daily discharges. In 1898, owever, careful estimates were prepared by Mr. Codman, the results eing given in the Twentieth Annual Report, Part IV, page 97.

The figures for daily discharge in the following table do not repre- ent the total flow of the stream, but the amount wasted over the flash- oards at Fairmount dam. To this must be added the pumpage from he river, also the leakage, and also the quantity used for power at Fair- ount. The total discharge is given at foot of the table of monthly otals in cubic feet. There has been no method for obtaining the daily ow when the water does not waste over the flashboards. When the ater is below the overflow line recourse is had to pumping, and the raft is on the storage of the pool. As soon as the water begins to ise after a rain the turbine wheels are started, and thus it often ccurs that no water flows to waste for from one to three months in uccession.

The following figures for 1902 were furnished by Mr. Codman:

Daily discharge, in second-feet, of Schuylkill River above Philadelphia, Pa., for the amount wasted over flashboards at Fairmount dam.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	D
1902.												
1	1,817	953	82,156	2,712	1,537		1,000			6,057	1,[illegible]	
2	4,938	1,964	25,172	1,819	896		305			4,814	1,[illegible]	
3	3,814	6,747	12,765	1,267	605					2,300	1,[illegible]	
4	2,120	4,556	5,297	1,308	92		416			1,443	1,[illegible]	
5	1,634	945	1,887	1,308			275			3,137	9[illegible]	
6	1,524	500	1,216	1,308	92					9,534	9[illegible]	
7	1,349	530	734	1,873						4,494	9[illegible]	
8	1,349	44	1,200	5,726						2,510	9[illegible]	
9	1,349		2,720	16,396						2,180	9[illegible]	
10	1,041	166	10,078	13,019				450		895	4[illegible]	
11	1,041	92	8,873	7,976				1,378	183	744	1[illegible]	
12	674	176	5,331	5,260				3,358		11,322	1[illegible]	
13	367	44	5,200	4,078				1,818		7,614	1[illegible]	
14	245		5,331	3,125	46			107		4,498	1[illegible]	
15	119	45	5,331	2,489	92					3,098	1[illegible]	
16	260		4,573	1,887						2,100	1[illegible]	
17	119	78	5,358	1,699	637					1,459	2[illegible]	
18	134		6,430	1,362	92					1,076	2[illegible]	
19	92		4,666	1,026	92					819	2[illegible]	
20	32		3,071	880						676	1[illegible]	
21	1,005	383	3,040	497						413	2[illegible]	
22	37,901	17,369	2,577	239			97			263	1[illegible]	
23	22,919	11,045	2,182	45						199	1[illegible]	
24	8,004	5,364	1,705	302						159	9[illegible]	
25	4,156	5,446	1,354	605			184			184	1[illegible]	
26	2,182	38,856	961	423	119				2,104	225	9[illegible]	
27	3,280	37,172	702	314		92			12,349	254	3[illegible]	
28	4,817	38,174	670	314					6,818	3,919	3,2[illegible]	
29	2,349		1,634	497					4,078	6,168	1,3[illegible]	
30	1,187		4,183	1,246		571	315		2,524	3,407	4[illegible]	
31	953		4,183				944			2,463		

Total monthly yield of Schuylkill River above Philadelphia, Pa., for 1[illegible]

	Cubic feet.
January	14,403,100,000
February	18,278,000,000
March	24,203,300,000
April	11,673,500,000
May	4,407,600,000
June	2,382,700,000
July	3,589,200,000
August	3,248,400,000
September	4,283,500,000
October	12,229,700,000
November	5,741,800,000
December	24,847,000,000

SUSQUEHANNA RIVER DRAINAGE BASIN.

The North Branch of this river rises in New York State and flows in a southwesterly direction until it crosses the Pennsylvania State line, when it changes its course to the southeast, turns again, near Wilkesbarre, to the southwest and joins the West Branch on the western border of Northumberland County, to form the Susquehanna proper. The West Branch rises in Cambria County, Pa., and flows in a general northeasterly direction until it joins the North Branch. Measurements of flow of the North Branch are made at Binghamton, N. Y., and at Wilkesbarre and at Danville, Pa., and of the West Branch at Allenwood and at Williamsport, Pa. At Binghamton the Chenango River unites with the North Branch of the Susquehanna and a gaging station is located at this place. The Juniata River, which rises in Center County, Pa., flows into the Susquehanna about 15 miles above Harrisburg. Most of its drainage area is mountainous and covered with forest growth. A gaging station is located on this branch at Newport, about 15 miles above the junction of the river with the Susquehanna. On the main branch of the Susquehanna River measurements are being made at Harrisburg. The measurements at these stations are made by E. G. Paul and R. E. Horton.

CHENANGO RIVER AT BINGHAMTON, N. Y.

The gage on this stream is located on the upstream side of the first span from the right bank of Court street bridge, in Binghamton.

It consists of a horizontal wooden box containing a scale graduated in feet and tenths to 15.5 feet, secured to the vertical supports of the hand railing by means of U-bolts. At the zero end of the scale is placed a pulley over which passes the weight wire. The bench mark is a circular chisel draft in upstream corner of bridge seat on left-hand abutment. Elevation of bench mark, 100 feet; elevation of water surface when gage reads zero, 65.98 feet.

The Court street bridge stands squarely across the stream, which has a nearly horizontal bed of gravel and small cobblestones, affording a smooth uniform current for gaging. The channel is obstructed by three masonry piers supporting the four spans of the bridge, 79 feet clear width each, the bridge having a total length of 337 feet between abutments. The bridge is situated 2,500 feet above the mouth of Chenango River. A small rift below the bridge cuts off backwater from Susquehanna River at ordinary stages of the rivers. During freshets, when the gage readings may be affected by backwater, making them appear too large, check readings are taken at De Forest street bridge, 1.4 miles upstream.

During 1901 nine current-meter measurements were made through the cooperation of E. C. Murphy.

The gage reader, E. F. Weeks, takes readings of the river stage twice daily. During freshets additional readings are taken at frequent intervals at the Chenango and Susquehanna stations by the United States Weather Bureau, of which W. E. Donaldson is official in charge at Binghamton.

Three-fourths mile above the gage is located the dam of the Binghamton Cold Storage Company. Six water wheels are used under a head varying from zero to 5 feet, rated at a total of 150 horsepower. The dam is a low structure, giving but 3-foot fall. It consists of large blocks of bluestone laid dry, offering numerous leaks and crevices. The dam affords little obstruction to the flow of the stream, which passes the gage in nearly its normal regimen.[a]

The flow at Binghamton does not represent the entire natural run-off of the Chenango drainage basin, as a portion of the headwaters are diverted across the Chenango-Mohawk divide through Oriskany Creek to feed the Rome or summit level of Erie Canal.[b]

Additional diversion takes place from the headwaters of Tioughnioga River through Fayetteville feeder. De Ruyter reservoir, at the head of the feeder, which has a tributary drainage of 18 square miles, receives most of its supply from across the Chenango divide.

Nominal and effective drainage areas of Chenango River above Binghamton.

	Square miles.
Natural drainage area above Binghamton	1,582
Area tributary to canal storage reservoirs	105
Effective area above Binghamton during navigation season	1,477

Discharge measurements of Chenango River at Binghamton, N. Y.

Date.	Hydrographer.	Gage height.[c]	Discharge.
1901.		*Feet.*	*Second-feet.*
July 29	E. C. Murphy	5.21	40
July 29	do	5.21	45
August 19	do	5.48	50
August 19	do	5.49	57
July 2	do	5.64	85
July 9	do	5.71	98
July 8	do	5.78	1,13
October 19	do	5.81	1,9
October 19	do	5.81	1,9

[a] See description of Chenango River in "Report on water power," part 1, Tenth United States Census, 1880, Vol. XVI, pp. 583-585.

[b] See description of Oriskany Creek station, p. 79.

[c] Datum elevation 65.98 feet.

[d] Subject to revision.

scharge measurements of Chenango River at Binghamton, N. Y.—Continued.

Date.	Hydrographer.	Gage height.	Discharge.
1902.		*Feet.*	*Second-feet.*
ugust 15	E. C. Murphy	6.08	1,341
ugust 14	do	6.20	1,608
ıly 15	do	6.56	2,098
ıne 6	R. E. Horton	6.58	2,407
ıly 3	E. C. Murphy	7.16	2,688
[arch 27	do	8.15	4,201
[arch 28	do	8.21	4,377
ıly 1	do	8.41	4,815
[arch 29	do	8.75	5,205
ıgust 3	do	9.04	5,543

Mean daily gage height, in feet, of Chenango River at Binghamton, N. Y.[a]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
1								5.18	5.58	5.70	5.46	6.12
2								5.08	5.75	5.50	5.31	6.33
3								5.10	5.58	5.52	5.26	6.61
4								5.10	5.50	5.68	5.28	6.52
5								5.05	5.43	5.55	5.27	6.19
6								5.20	5.28	5.51	5.25	5.95
7								5.01	5.23	5.45	5.25	5.91
8								5.10	5.20	5.47	5.23	6.03
9								5.20	5.18	5.40	5.24	6.86
10								5.20	5.15	5.37	5.21	9.64
11								5.23	5.15	5.34	5.14	10.00
12								5.20	5.18	5.34	5.26	8.82
13								5.18	5.30	5.42	6.85	.....
14								5.13	5.48	6.47	6.45	8.48
15								5.15	5.35	6.41	6.20	19.54
16								6.35	5.43	6.08	6.11	18.02
17								5.90	5.55	5.89	6.10	12.61
18								5.60	5.63	5.85	6.06	9.42
19								5.48	5.55	5.80	6.06	8.11
20								5.40	5.45	5.82	6.00	7.40
21								5.55	5.45	5.78	5.96	6.84
22								5.58	5.30	5.75	5.96	6.67
23								5.48	5.23	5.70	5.94	6.77
24								6.70	5.20	5.67	6.72	8.18
25								6.20	5.25	5.57	7.78	7.42
26								5.65	5.24	5.48	7.19	6.89
27								5.38	5.25	5.45	6.64	6.84
28								5.30	.....	5.39	6.06	6.50
29								5.25	5.15	5.40	6.20	6.53
30								5.20	5.88	5.35	6.33	7.20
31								5.20	.....	5.39	.....	7.36

[a] Tables give actual gage readings. Datum changes from 65.98 to 65.57 August 21, 1902.

Mean daily gage height, in feet, of Chenango River at Binghamton, N. Y.—Cont'd

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	De.
1902.												
1	6.62	6.31	19.44	8.65	6.58	6.20	8.50	8.33	6.08	7.73	8.0	6.
2	6.64	6.26	23.32	8.61	6.30	6.08	7.80	9.33	5.98	7.70	8.00	6.
3	6.74	6.13	21.64	8.45	6.20	5.95	7.31	8.35	6.00	7.13	7.70	7.
4	6.91	6.34	17.15	8.10	6.20	6.23	7.35	7.70	5.98	6.73	7.6	7.
5	6.65	6.20	12.80	7.83	6.20	6.95	7.05	7.20	5.90	6.48	7.3	7.
6	6.61	6.19	9.98	7.70	6.10	6.58	7.38	6.88	5.88	6.73	7.0	7.
7	6.52	6.16	9.25	7.60	6.10	6.30	8.12	6.90	5.93	7.00	7.15	7.
8	6.30	6.20	9.03	7.57	6.10	6.30	7.93	6.75	5.90	6.88	7.08	6.
9	6.22	6.21	8.67	8.12	6.10	6.33	7.73	6.68	5.93	6.90	6.9	6.
10	6.13	6.08	9.45	8.50	5.98	6.30	7.80	6.45	6.30	6.73	6.7	6.
11	6.14	6.10	9.28	8.97	5.95	8.45	9.15	6.40	6.53	6.58	6.73	7.
12	6.02	5.99	11.60	8.78	5.90	6.33	8.33	6.65	6.25	6.60	6.6	7.
13	5.87	5.90	15.08	8.48	5.85	6.25	7.33	6.60	6.10	6.60	6.5	6.
14	5.68	5.84	15.77	8.23	5.80	6.30	6.88	6.29	6.05	6.60	6.6	6.
15	5.89	5.77	14.17	7.80	5.75	6.20	6.60	6.13	6.00	7.08	6.7	6.
16	5.91	5.87	11.97	7.48	5.70	6.18	6.48	6.10	5.90	6.75	6.6	6.
17	5.89	5.76	15.87	7.18	5.73	6.20	6.48	5.98	5.85	6.55	6.5	6.
18	5.76	5.78	15.72	7.05	5.70	6.10	6.40	5.98	5.80	6.45	6.5	6.
19	5.78	5.74	13.10	6.90	5.60	6.00	6.73	5.88	5.80	6.40	6.5	6.
20	5.78	5.71	10.47	6.80	5.75	6.00	11.57	5.88	5.75	7.25	6.5	6.
21	5.67	5.64	9.40	6.70	6.00	5.95	14.98	6.15	5.73	7.30	6.7	6.
22	6.02	5.67	9.20	6.68	5.88	6.20	14.90	6.44	5.70	6.95	6.8	6.
23	8.24	5.68	9.32	6.50	5.78	6.25	13.40	6.35	5.73	6.78	6.5	6.
24	8.66	5.67	9.38	6.38	5.83	6.08	12.22	6.33	5.73	6.75	6.6	6.
25	7.62	5.69	8.90	6.30	5.95	5.93	11.35	6.28	5.75	6.75	6.6	6.
26	6.87	5.73	8.47	6.18	6.80	5.98	9.60	6.25	5.98	6.65	6.7	6.
27	6.86	6.08	8.15	6.18	6.58	6.10	8.50	6.15	6.20	6.60	7.2	6.
28	7.28	8.42	8.15	6.13	6.30	6.08	11.50	6.23	6.10	10.19	7.9	6.
29	7.39	.....	8.90	6.13	6.20	6.65	9.58	6.18	8.08	12.15	7.2	6.
30	6.86	.....	9.28	6.28	6.18	10.48	8.50	6.18	6.88	10.85	7.6	6.
31	6.41	.....	8.97	.....	6.15	.....	9.18	6.10	.....	9.30	.....	6.

SUSQUEHANNA RIVER AT BINGHAMTON, N. Y.

A gaging station was established on this stream July 31, 1[9]. The gage is located on the upstream side of the left span of [the] Washington street bridge. This bridge is situated about 800 [feet] upstream from the junction of Chenango and Susquehanna rivers. A rift extends diagonally across the stream underneath the bridge. The gage stands above a stretch of smooth water extending from the crest of the rift to the dam, 2,800 feet upstream, and the gage readings are unaffected by backwater from Chenango River at ordinary stages. Owing to unfavorable conditions underneath the Washington street bridge, discharge measurements are made at Exchange street bridge, 1,900 feet upstream. The gage is of the weight-and-wire variety, reading to feet and tenths, its datum being determined as follows:

Bench mark, chisel draft on corner left-hand bridge abutment, upstream side, elevation 100.00
Elevation water surface, when gage reads zero 76.39

The gage is read twice daily by E. F. Weeks.

There are no tributaries of noticeable magnitude entering between e gaging stations on the Chenango and Susquehanna rivers at Bingamton and the junction of the two streams. Simultaneous discharge easurements of the two streams were made on several occasions. y combining the flow of the two branches, that of the Susquehanna elow the junction at Binghamton has been obtained, as follows:[a]

By taking levels of high-water marks furnished by the mill owners, ie following data relative to flood discharge of Susquehanna River ave been obtained:

Flood discharge of Susquehanna River.

Date.	Depth on crest of present dam.	Estimated discharge.
	Feet.	*Second-feet.*
larch, 1865	13.8	----------
Highest since 1865 (prior to 1901)	9.0	41,000
898 and 1899	9.0	38,000
901 (spring)	7.4	38,000

A current-meter measurement made at the highway bridge at Union, N. Y., by R. E. Horton, June 6, 1902, showed a discharge of 5,475 second-feet. Elevation of water surface referred to Delaware, Lackawanna and Western Railroad datum, 803.88. The drainage area at Union is 4,032 square miles. The accompanying tables show the progress of the floods of December 15–16, 1901, and March 1–2, 1902; the latter exceeded all known previous floods except that of 1865. The following comparative data have been obtained from these two floods at Binghamton and at Union highway bridge, 8.8 miles below the gaging station. Elevations were referred to the Delaware, Lackawanna and Western Railroad datum or mean tide at Sandy Hook.

Elevation of water surface of Susquehanna River at Binghamton and Union.

Flood.	Elevation at Binghamton.	Elevation at Union.	Fall.
			Feet.
December 15–16, 1901	835.67	820.59	15.08
March 1–2, 1902	839.77	826.71	13.06
——, 1865	840.00	827.82	12.18

From the stage and slope as given above and from cross sections obtained, the discharge during these freshets has been calculated by means of the Kutter formula. The coefficient of roughness $n=0.040$

[a] See description Chenango River, page 148.

has been used, this value having been calculated from observed slope and measured discharges at lower stages of the stream.

Flood discharge of Susquehanna River, estimated by Kutter formula.

Flood.	Estimated discharge.	Per square mile
	Second-feet.	*Second-feet.*
December 15–16, 1901	67,160	16.7
March 1–2, 1902	104,470	25.9
——— —, 1865	104,770	26.0

Total flow of Susquehanna River below junction.

1901.	Second-feet.
July 2–3	1,795
July 8–10	2,544
July 29–30	1,013
August 19–20	1,519
Do	1,515

Estimated drainage areas of Susquehanna and Chenango rivers, above Binghamton, N. Y.

	Square miles.
Susquehanna above Oneonta	686
Susquehanna above mouth of Unadilla River	914
Unadilla River above junction with Susquehanna	565
Susquehanna River below mouth of Unadilla River	1,479
Susquehanna, total drainage in New York above Chenango	1,900
Susquehanna, drainage in Pennsylvania above Chenango	500
Susquehanna River, total above Chenango River	2,400
Chenango River above Chenango Forks	694
Tioughnioga River above junction with Chenango River	753
Chenango River below mouth of Tioughnioga River	1,447
Chenango River above mouth	1,582
Susquehanna River below junction of Chenango River	3,982

The Susquehanna gage is located a short distance below the Binghamton Water Power dam, and the records show the amount passed by the turbines or wasting over spillway each day. The dam was built in 1833 by Whitney and Waterman. In 1869 it was repaired and its crest raised by the State of New York, and it now furnishes water power to four mills under an effective head of 6 feet.

Water-power privileges at Susquehanna River dam, Binghamton, N. Y.

Firm.	Business.	Water rights, etc.
H. J. Lyon's Sons	Saw and planing mill	First privilege, unlimited.
Luke Doolittle	Custom grinding	For 1 reaction water wheel.
Binghamton Box Co	Cigar boxes	Specified number of square inches.
Wilkinson Manufacturing Co.	Novelty works	Do.

The following tables show the variation of the gage readings during the floods of 1901 and 1902:

Variations in gage readings during flood of December 15–16, 1901, at Binghamton, N. Y.

Date.	Susquehanna River.		Chenango River.	
	Time.	Gage.	Time.	Gage.
December 15	8.45 a. m.	14.44	9.10 a. m.	18.73
	12.30 p. m.	14.94	11.00 a. m.	19.45
	5.30 p. m.	15.64	5.00 p. m.	20.45
December 16	8.00 a. m.	14.59	7.30 a. m.	18.63
	11.00 a. m.	14.19	11.30 a. m.	17.90
	4.30 p. m.	12.89	5.00 p. m.	16.50
December 17	7.50 a. m.	10.29	7.20 a. m.	13.73
			2.45 p. m.	12.20
			4.50 p. m.	11.90

Variations in gage readings during flood of March 1–2, 1902, at Binghamton, N. Y.

Date.	Susquehanna River.		Chenango River.	
	Time.	Gage.[a]	Time.	Gage.
February 28	7.35 a. m.	3.54	7.15 a. m.	5.95
	2.00 p. m.	5.44	1.20 p. m.	8.50
	4.30 p. m.	7.84	5.00 p. m.	11.32
March 1	7.25 a. m.	13.79	7.05 a. m.	17.38
	9.00 a. m.	14.09	8.45 a. m.	17.80
	10.50 a. m.	14.49	10.40 a. m.	18.10
	1.30 p. m.	14.99	1.05 p. m.	18.60
	3.10 p. m.	15.19	3.00 p. m.	19.10
	5.00 p. m.	16.54	4.00 p. m.	20.10
	7.20 p. m.	17.59	7.30 p. m.	21.50
March 2	7.40 a. m.	19.74	8.00 a. m.	22.80
	10.30 a. m.	18.69	11.00 a. m.	22.60
	1.55 p. m.	18.79	1.35 p. m.	22.60
	4.00 p. m.	18.79	4.20 p. m.	22.70
	7.35 p. m.	18.99	8.20 p. m.	22.90
			10.30 p. m.	23.10

[a] Referred to No. 1 or original gage.

Variations in gage readings during flood of March 1–2, 1902, at Binghamton, N. Y.—Continued.

Date.	Susquehanna River.		Chenango River.	
	Time.	Gage.	Time.	Gage.
March 3	7.55 a. m.	18.69	7.30 a. m.	22.56
	9.15 a. m.	18.39	9.00 a. m.	22.30
	1.30 p. m.	17.99	11.30 a. m.	21.95
	7.30 p. m.	16.99	1.00 p. m.	21.70
			3.40 p. m.	21.46
			7.00 p. m.	20.80
March 4	7.20 a. m.	14.89	7.00 a. m.	18.40
	1.15 p. m.	13.74	12.00 a. m.	17.30
	3.15 p. m.	13.34	3.25 p. m.	16.60
	5.00 p. m.	12.99	5.30 p. m.	16.30
March 5	7.45 a. m.	10.19	7.00 a. m.	13.65
	5.00 p. m.	8.49	4.30 p. m.	11.95
March 6	7.55 a. m.	6.79	7.30 a. m.	10.35
	4.45 p. m.	6.24		

Discharge measurements of Susquehanna River at Binghamton, N. Y.

Date.	Hydrographer.	Gage height.[a]	Discharge.
1901.		*Feet.*	*Sec.-ft.*
July 30	E. C. Murphy	1.99	60[illegible]
August 20	do	2.09	9[illegible]
Do	do	2.10	6[illegible]
July 3	do	2.12	9[illegible]
July 10	do	2.35	1,425
August 23	do	2.64	2,176
August 22	do	2.94	2,9[illegible]
Do	do	3.23	3,7[illegible]
August 21	do	4.64	7,344
1902.			
August 16	E. C. Murphy	2.50	1,9[illegible]
August 15	do	2.61	2,10[illegible]
July 14	do	2.96	3,0[illegible]
July 4	do	3.90	5,2[illegible]
July 2	do	4.08	5,8[illegible]
August 4	do	4.59	6,90[illegible]
August 3	do	5.08	8,633

[a] All gage readings reduced to original gage (No. 1). Datum = 76.29.

Daily gage height, in feet, of Susquehanna River at Binghamton, N. Y.[a]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1901.												
								1.87½	2.25	2.75	2.6	3.05
								2.0	2.2	2.75	2.57	3.05
								1.95	2.2	2.72½	2.5	3.2
								1.9	2.25	2.72½	2.5	3.12
								1.9	2.22½	2.7	2.52	3.2
								1.9	2.2	2.62½	2.5	3.0
								1.9	2.1	2.6	2.5	2.88
								1.95	2.07½	2.55	2.5	2.9
								1.95	2.07½	2.6	2.47	3.0
								1.9	2.0	2.55	2.5	5.76
								1.97½	2.02½	2.57½	2.47	6.68
2								1.97½	2.1	2.52½	2.52	5.88
3								1.95	2.07½	2.55	3.05	.....
4								2.0	2.05	2.62½	3.52	5.18
5								1.97½	2.12½	2.7	3.35	15.42
6								1.97½	2.2	2.87½	3.10	14.3
7								2.0	2.25	2.95	3.0	9.8
8								2.15	2.4	.....	2.98	6.22
9								2.2	2.4	2.82½	2.92	4.85
10								2.1	2.37½	2.8	2.95	3.05
11								3.7	2.27½	2.8	2.95	3.52
12								3.02½	2.2	2.82½	2.88	3.32
13								2.65	2.1	2.8	2.85	4.3
14								4.55	2.1	2.75	3.28	5.22
15								3.9	2.1	2.7	3.98	4.52
16								3.25	2.07½	2.65	3.5	3.88
17								2.82½	2.3	2.62½	3.08	3.88
18								2.5	.....	2.62½	2.8	3.42
19								2.4	2.57½	2.6	2.9	3.45
20								2.3	2.6	2.6	2.95	3.25
21							1.95	2.35	.....	2.12½	.....	4.62

[a] Means of actual readings of gage. Datum as follows:

July 31, 1901, to September 26, 1901	76.29
September 27, 1901, to March 27, 1902	75.88
After March 27, 1902	75.65

Mean daily gage height, in feet, of Susquehanna River at Binghamton, N. Y.—Continued.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	Dec.
1902.												
1	3.78	3.10	16.10	5.95	3.60	3.10	5.85	5.65	2.88	5.33	5.35	
2	3.95	3.10	19.39	5.85	3.60	2.13	4.98	6.68	2.88	5.00	4.88	
3	3.78	3.18	18.39	5.68	3.50	3.05	4.35	6.02	2.88	4.43	4.45	
4	4.13	3.80	14.26	5.30	3.40	3.38	4.63	5.25	2.90	4.10	4.23	
5	3.78	3.53	9.75	4.95	3.40	3.83	4.18	4.53	2.88	3.85	4.03	
6	3.70	3.23	6.92	4.80	3.43	3.60	4.73	4.20	2.83	3.68	3.98	
7	3.58	3.28	6.15	4.65	3.33	3.38	5.18	4.13	2.80	3.58	3.83	
8	3.38	3.30	5.90	4.58	3.28	3.33	5.10	3.85	2.85	3.53	3.75	
9	3.23	3.35	5.60	5.50	3.20	3.40	4.75	3.73	2.83	3.50	3.58	
10	3.10	3.28	6.30	6.15	3.20	3.35	4.78	3.58	3.00	3.43	3.53	
11	3.08	3.40	6.15	6.45	3.10	3.23	5.53	3.48	3.00	3.30	3.45	
12	3.25	3.20	8.37	6.20	3.08	3.23	5.13	3.50	3.00	3.43	3.40	
13	3.13	2.98	11.75	5.78	3.05	3.38	4.18	3.55	2.98	3.53	3.40	
14	3.08	2.90	12.50	5.45	3.05	3.33	3.53	3.50	2.90	3.65	3.50	
15	2.90	2.80	11.17	5.10	3.03	3.40	3.50	3.35	2.90	3.65	3.43	
16	2.88	2.88	8.98	4.73	3.00	3.40	3.45	3.24	2.85	3.63	3.30	
17	2.80	2.75	18.57	4.45	3.00	3.28	3.38	3.15	2.80	3.50	3.20	
18	2.78	2.70	12.43	4.28	2.90	3.30	3.40	3.10	2.80	3.35	3.28	
19	2.98	2.73	10.02	4.13	2.90	3.25	3.40	3.05	2.80	3.25	3.23	
20	3.20	2.73	7.38	3.93	2.90	3.25	7.53	3.05	2.75	3.35	3.25	
21	2.70	2.75	6.27	3.83	3.00	3.20	11.80	3.10	2.70	3.50	3.20	
22	3.13	2.68	6.05	3.73	3.08	3.23	12.10	3.10	2.70	3.48	3.20	
23	5.33	2.88	6.17	3.60	3.10	3.33	10.75	3.08	2.75	3.33	3.23	
24	5.73	2.85	6.32	3.43	3.00	3.25	9.65	3.03	2.73	3.28	3.20	
25	4.78	2.73	6.00	3.38	2.95	3.13	8.85	3.00	2.75	3.28	3.23	
26	3.95	2.68	5.47	3.30	3.13	3.03	7.12	3.00	3.10	3.25	3.28	
27	3.70	2.98	5.12	3.25	3.30	3.13	6.15	2.95	3.38	3.20	3.45	
28	4.23	5.50	5.00	3.28	3.28	3.13	8.27	3.00	3.30	7.10	3.60	
29	4.58	.....	6.05	3.28	3.23	3.60	6.60	3.03	5.75	9.05	3.65	
30	3.90	.....	6.45	3.35	3.15	3.68	5.55	3.03	4.55	7.90	3.58	
31	3.43	.....	6.27	.....	3.10	.....	6.15	2.93	.....	6.28	.....	

NORTH BRANCH OF SUSQUEHANNA RIVER AT WILKESBARRE, PA.

Observations of fluctuations of Susquehanna River are made by the Weather Bureau above Wilkesbarre, at Towanda, Pa., where the drainage area is estimated to be 8,000 square miles. The river gage, made of iron 1 foot wide and one-half inch thick, is on the east side of the road bridge over Susquehanna River, and is securely bolted to the masonry of the pier. The graduation is from 0 to 25 feet. The highest water was 29 feet in March, 1869, and the lowest, —0.1, in October, 1895. The danger line is at 16 feet. The elevation of the zero is 633.7 feet.

The Wilkesbarre station was established by E. G. Paul on March 30, 1899, and is located at the Market street bridge. The gage is a sash chain and weight inclosed in a long, narrow box, covering 12 feet of the scale board. The scale board is divided into feet and tenths

and painted the color of the ironwork. The length of the chain from zero to extreme end of weight is 40.83 feet. The initial point of sounding is at the end of the iron guard rail on the left bank. The channel is straight for a quarter of a mile above and below the station, the current sluggish but unobstructed. The right bank is low and liable to overflow; the left bank is above ordinary floods. The bed of the stream is of sand and gravel, somewhat shifting. The observer is W. S. Bennett, Wilkesbarre, Pa. When this gage was established there was found to be a gage painted on the bridge pier, being a portion of one established by the Weather Bureau. The lower part of this gage, erected in January, 1898, originally consisted of heavy cast-brass plates graduated to feet and tenths. The gage plates were made in 4-foot sections and bolted to the stone bridge pier. The two lower sections of the brass plates had been torn away by ice, so that there was no graduation below the 8-foot mark, but readings were made by the figures painted on the stone pier. The zero of this old gage is at the base of the dressed-stone portion of the pier, and is reported to be 535 feet above sea level. During low stages of the river the water recedes from the pier, rendering it impracticable to read the gage. So far as could be ascertained, this has not been connected with the city datum. On account of the low water, which in 1897 had gone below the city datum, it was decided to put the zero of the new gage 4 feet below the zero of the old Weather Bureau gage, so as to obviate minus readings. In order, therefore, to compare with former records, it is necessary to add 4 feet to the old figures. The danger mark of this Weather Bureau gage is at 14 feet, or 18 feet of new gage, as at this elevation the west bank of the river is under water in places. River reports from this locality were furnished as early as 1888. During low water, measurements were made by wading at a better cross section, at Retreat, 10 miles below Wilkesbarre. A bench mark was established September 26, 1900, being the extreme west end of the stone doorsill of the north entrance to the Coal Exchange Building, at 32.99 feet above datum of the gage. During 1902 measurements of discharge were made by Mr. Paul, as follows:

September 20: Gage height, 3.1 feet; discharge, 2,170 second-feet.

Daily gage height, in feet, of North Branch Susquehanna River at Wilkesbarre, Pa.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	14.00	12.70	29.57	9.70	5.00	4.10	10.60	8.80	3.60	9.60	9.55	11.
2	13.00	11.40	30.75	9.20	4.90	4.00	10.50	9.50	3.50	10.60	9.25	10.
3	12.10	10.80	30.05	9.00	5.10	3.90	8.30	11.10	3.40	10.60	7.90	9.
4	10.90	10.70	25.25	8.50	5.10	3.90	7.80	9.60	3.40	8.50	6.80	8.
5	9.60	8.50	20.20	8.10	4.80	3.80	8.50	8.80	3.20	7.30	6.60	8.
6	9.90	7.00	14.65	7.90	4.80	3.80	8.25	7.50	3.20	7.10	6.00	8.
7	9.80	9.10	11.65	7.60	4.70	4.80	12.70	6.80	3.20	6.90	5.80	7.
8	9.60	9.80	10.70	7.70	4.70	4.50	14.20	6.50	3.20	6.70	5.50	7.
9	9.70	9.60	10.30	11.85	4.50	4.40	13.15	6.20	3.20	6.20	5.60	7.
10	9.40	9.40	11.00	15.80	4.40	4.20	8.75	5.80	3.20	5.80	5.70	7.
11	9.20	9.00	12.50	15.45	4.30	4.20	9.00	5.60	3.60	5.50	5.00	7.
12	9.00	9.00	14.80	12.80	4.20	4.20	9.70	5.50	3.50	5.80	4.70	6.
13	8.20	9.00	18.00	14.40	4.10	4.10	8.50	5.40	3.60	6.50	4.70	6.
14	7.20	8.30	19.60	10.30	4.00	4.20	7.40	5.40	3.50	6.00	4.70	5.
15	6.40	8.00	18.20	9.40	3.90	4.20	6.30	5.20	3.50	5.80	4.70	5.
16	6.80	8.20	15.80	8.60	3.80	4.20	5.80	5.00	3.40	5.90	4.60	5.
17	7.20	7.80	18.50	8.00	3.80	5.00	5.40	4.60	3.30	5.90	4.50	5.
18	7.00	7.70	20.20	7.40	3.70	4.70	5.20	4.40	3.30	5.60	4.40	5.
19	6.70	7.20	17.45	7.00	3.70	4.40	5.10	4.20	2.20	5.30	4.30	5.
20	6.10	6.60	14.30	6.70	3.60	4.60	5.40	4.10	3.10	4.90	4.20	5.
21	6.20	6.60	11.60	6.40	3.50	4.30	12.10	4.00	3.10	4.80	4.20	5.
22	10.60	6.50	10.20	6.20	3.50	4.30	15.90	4.00	3.00	4.90	4.20	5.
23	16.70	6.40	9.70	6.00	3.50	4.20	13.90	4.00	3.00	5.20	4.10	5.
24	12.20	7.20	9.60	5.70	3.70	4.20	13.45	3.90	3.00	5.00	4.10	5.
25	10.70	7.20	9.50	5.50	3.70	4.20	13.85	3.90	3.00	4.70	4.10	5.
26	9.70	7.70	9.00	5.20	3.70	4.20	14.90	3.80	4.20	4.70	4.10	5.
27	8.90	8.80	8.50	5.00	3.80	4.10	11.70	3.70	7.10	4.60	4.50	5.
28	8.20	14.03	8.00	4.80	3.90	3.90	9.70	3.60	6.00	7.62	4.70	5.
29	7.70	.....	9.00	4.70	4.60	3.80	10.80	3.60	7.90	11.05	5.00	5.
30	7.60	.....	10.40	4.90	4.60	5.10	10.60	3.60	10.70	12.05	5.50	7.
31	13.30	.....	9.80	.....	4.20	.....	9.30	3.60	.....	11.10	.....	6.

Rating table for North Branch of Susquehanna River at Wilkesbarre, Pa., for ...

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.2	1,000	4.6	4,340	7.0	13,600	13.0	47,800
2.4	1,200	4.8	4,760	7.5	16,400	13.5	50,000
2.6	1,400	5.0	5,200	8.0	19,200	14.0	52,800
2.8	1,600	5.2	5,700	8.5	22,000	14.5	55,600
3.0	1,860	5.4	6,250	9.0	24,800	15.0	58,400
3.2	2,120	5.6	6,850	9.5	27,600	15.5	61,200
3.4	2,400	5.8	7,560	10.0	30,400	16.0	64,000
3.6	2,700	6.0	8,340	10.5	33,200	16.5	66,800
3.8	3,000	6.2	9,240	11.0	36,000	17.0	69,600
4.0	3,300	6.4	10,260	11.5	38,800	.....	.....
4.2	3,600	6.6	11,360	12.0	41,600	.....	.....
4.4	3,940	6.8	12,480	12.5	44,400	.....	.....

timated monthly discharge of North Branch Susquehanna River at Wilkesbarre, Pa.

[Drainage area, 9,810 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
nuary	67,920	8,770	27,123	2.76	3.19
bruary	52,968	10,260	23,247	2.37	2.47
arch	146,768	19,200	59,086	6.02	6.94
oril	62,880	4,540	21,633	2.21	2.47
ay	5,450	2,550	3,679	.37	.43
ne	5,950	3,000	3,732	.38	.42
ly	63,440	5,450	30,088	3.07	3.54
ugust	36,560	2,700	9,069	.92	1.06
ptember	34,320	1,860	4,511	.46	.51
ctober	41,880	4,340	13,878	1.41	1.63
ovember	27,600	3,450	6,890	.70	.78
ecember	73,240	5,200	26,138	2.66	3.07
The year	146,768	1,860	19,090	1.94	26.51

NORTH BRANCH OF SUSQUEHANNA RIVER AT DANVILLE, PA.

This station, 52 miles below Wilkesbarre and 11 miles above the mouth of the West Branch, was established on March 25, 1899, by E. G. Paul. It is located at the Mill street bridge, 600 feet south of the public square, Danville, Pa. The equipment consists of a standard chain and weight gage referred to a horizontal scale board graduated to feet and tenths, inclosed in a lock box bolted to the hand rail on the lower side of the bridge, 200 feet from the right bank. The length of the chain from the zero to the extreme end of the weight is 42.85 feet. The initial point of soundings is at the end of the wooden hand rail on right bank. The channel is straight for half a mile above and below the station. The left bank is high, but the right bank is subject to overflow. The bed of the stream is rocky, with some gravel, and is unchangeable. A bench mark was established, being the extreme south end of the stone doorsill at the east entrance of the city filtering plant, at 31.7 feet above datum of the gage. During 1902 two measurements were made by Mr. Paul, as follows:

April 22: Gage height, 5.25 feet; discharge, 14,393 second-feet.
September 19: Gage height, 2.75 feet; discharge, 3,115 second-feet.

Daily gage height, in feet, of North Branch of Susquehanna River at Danville, Pa.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	Dec
1902.												
1	6.60	4.85	20.67	7.85	4.40	3.50	6.10	7.70	3.10	8.85	7.45	4.3
2	6.20	5.05	24.43	7.60	4.30	3.40	8.95	7.75	3.00	9.15	6.35	4.2
3	5.40	(a)	26.07	7.40	4.20	3.30	7.40	8.70	3.00	9.05	5.80	4.2
4	5.50	.....	22.25	7.10	4.20	3.30	6.90	8.20	2.90	7.65	5.45	4.0
5	6.70	.....	18.20	6.65	4.20	3.30	6.90	7.20	2.90	6.75	5.20	4.1
6	(a)	.....	14.50	6.45	4.10	3.20	6.90	6.75	2.80	6.60	5.00	4.0
7	.....	.....	10.75	6.30	4.00	3.20	8.50	5.85	2.80	6.50	4.85	4.0
8	.....	.....	8.55	6.50	4.00	3.90	11.90	5.45	2.80	6.10	4.70	4.0
9	10.60	.....	8.35	7.30	3.90	3.70	10.45	5.20	2.70	5.60	4.70	4.1
10	9.45	.....	9.10	11.90	3.80	3.50	7.85	5.00	2.90	5.20	4.60	4.1
11	9.10	.....	10.25	13.10	3.80	3.50	7.25	4.70	3.00	4.90	4.30	4.0
12	9.30	.....	11.55	11.20	3.70	3.60	7.80	4.60	3.10	5.40	4.50	4.1
13	(a)	.....	14.15	9.75	3.60	3.50	7.90	4.50	3.00	6.00	4.10	4.0
14	.....	.....	16.15	8.65	3.50	3.50	7.20	4.50	3.10	5.60	4.00	3.9
15	.....	.....	15.55	7.70	3.50	3.60	5.55	4.40	3.10	5.35	3.95	4.0
16	.....	.....	13.95	7.05	3.40	3.60	5.15	4.30	3.00	5.10	3.90	3.9
17	.....	.....	14.25	6.60	3.30	3.70	4.85	4.10	2.90	5.10	3.90	3.9
18	.....	.....	16.60	6.35	3.30	4.10	4.60	3.80	2.80	5.00	3.80	3.8
19	.....	.....	15.60	6.15	3.20	4.00	4.40	3.70	2.70	4.70	3.70	3.8
20	.....	.....	12.80	5.90	3.10	3.80	4.40	3.60	2.60	4.50	3.60	3.9
21	.....	.....	10.95	5.45	3.10	3.80	5.30	3.50	2.60	4.30	3.60	3.9
22	16.30	.....	8.90	5.30	3.10	3.70	11.90	3.50	2.60	4.10	3.60	12.7
23	8.10	.....	8.00	5.10	3.00	3.60	12.00	3.40	2.60	4.20	3.50	14.9
24	9.45	.....	6.40	4.90	3.00	3.50	11.30	3.40	2.50	4.30	3.50	14.6
25	8.50	.....	7.20	4.70	3.20	3.50	10.90	3.40	2.60	4.20	3.50	13.4
26	7.40	.....	7.10	4.50	3.30	3.60	11.90	3.30	4.75	4.00	3.60	9.7
27	6.90	.....	7.05	4.30	3.20	3.70	10.20	3.20	6.85	5.60	3.80	7.4
28	6.75	13.75	6.65	4.10	3.30	3.70	8.30	3.20	6.20	8.90	3.90	7.6
29	6.40	.....	6.75	4.00	3.50	3.50	8.00	3.20	6.05	9.70	4.00	6.9
30	6.20	.....	8.15	4.30	3.80	4.20	9.30	3.10	7.95	9.35	4.20	6.3
31	5.55	.....	8.30	.....	3.70	.....	8.20	3.10	.....	8.20	.....	5.7

a Frozen January 6 to 8, 13 to 21, and February 3 to 27.

ting table for North Branch of Susquehanna River at Danville, Pa., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.6	825	4.8	11,500	8.0	33,200	16.0	90,800
1.8	1,100	5.0	12,550	8.5	36,800	16.5	94,400
2.0	1,400	5.2	13,720	9.0	40,400	17.0	98,000
2.2	1,800	5.4	14,900	9.5	44,000	17.5	101,600
2.4	2,250	5.6	16,100	10.0	47,600	18.0	105,200
2.6	2,750	5.8	17,390	10.5	51,200	18.5	108,800
2.8	3,300	6.0	18,800	11.0	54,800	19.0	112,400
3.0	3,900	6.2	20,240	11.5	58,400	19.5	116,000
3.2	4,550	6.4	21,680	12.0	62,000	20.0	119,600
3.4	5,250	6.6	23,120	12.5	65,600	20.5	123,200
3.6	6,000	6.8	24,560	13.0	69,200	21.0	126,800
3.8	6,800	7.0	26,000	13.5	72,800	21.5	130,400
4.0	7,650	7.2	27,440	14.0	76,400	22.0	134,000
4.2	8,575	7.4	28,880	14.5	80,000	.....	.....
4.4	9,525	7.6	30,320	15.0	83,600	.....	.....
4.6	10,500	7.8	31,760	15.5	87,200	.....	.....

stimated monthly discharge of North Branch of Susquehanna River, at Danville, Pa.

[Drainage area, 11,070 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January [a]	.....	.....	[b] 32.645	[b] 2.95	[b] 2.08
February [a]	.....	.....	.....	.....	.....
March	163,160	23,480	66,215	5.98	6.89
April	69,920	7,650	25,183	2.27	2.53
May	9,525	3,900	6,123	.55	.63
June	8,575	4,550	6,032	.54	.60
July	62,000	9,525	33,550	3.03	3.49
August	38,240	4,200	12,498	1.13	1.30
September	32,840	2,500	6,485	.59	.66
October	45,440	7,650	20,594	1.86	2.14
November	26,360	5,600	9,638	.87	.97
December	82,160	8,575	28,637	2.59	2.99

[a] Frozen, and no record for January 6 to 8, 13 to 21, and February 3 to 27.
[b] Partial month; 19 days.

WEST BRANCH OF SUSQUEHANNA RIVER AT WILLIAMSPORT, PA.

Observations of the water height on the West Branch have been made for several years from the Market street bridge. Bench mark and datum for observer's gage were established March 1, 1895, under the direction of Mr. George D. Snyder, city engineer, and since that time daily gage heights have been observed. F. A. Snyder, the present city engineer, supplies this office with daily gage-height reports. On August 16, 1901, a discharge measurement was made, and a United States Geological Survey standard chain gage was installed on the upper side of the bridge, for convenience in making the daily observations. The length of the chain from the zero to the extreme end of the weight is 42.29 feet. A bench mark cut in the face of the left bank abutment is 10 feet above the datum of the gage.

The following discharge measurements were made during 1902 by E. G. Paul:

April 20: Gage height, 3.9 feet; discharge, 9,318 second-feet.
September 18: Gage height, 0.41 feet; discharge, 1,006 second-feet.

Daily gage height, in feet, of West Branch of Susquehanna River at Williamsport, Pa.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	3.20	4.30	20.38	6.00	2.50	1.30	8.30	5.00	0.50	2.70	1.90	
2	2.90	4.20	21.10	5.70	2.50	1.20	7.40	4.90	.60	4.10	1.70	
3	2.60	5.00	16.45	5.30	2.40	1.20	6.40	4.60	.50	3.10	1.60	
4	2.50	4.70	13.00	4.90	2.70	1.10	9.70	4.30	.50	2.50	1.50	
5	2.40	4.50	10.00	4.50	2.70	1.10	10.80	3.80	.50	2.40	1.40	
6	2.30	4.00	8.10	4.30	2.90	1.30	8.60	3.30	.40	2.30	1.40	
7	2.30	3.90	6.80	4.50	2.90	1.20	8.80	3.10	.40	2.20	1.30	
8	2.30	3.70	5.90	4.70	3.20	1.20	7.30	3.00	.40	2.20	1.40	
9	2.40	3.60	5.30	13.30	3.40	1.10	6.30	2.80	.40	2.00	1.40	
10	2.40	3.40	5.50	16.60	3.20	1.00	6.00	2.60	.60	1.80	1.30	
11	2.40	3.30	6.30	12.90	3.00	1.10	7.70	2.40	.50	1.60	1.30	
12	2.40	3.00	7.10	10.30	2.80	1.10	7.20	2.20	.50	1.40	1.30	
13	2.40	2.90	9.60	8.40	2.60	1.30	6.30	2.50	.60	1.20	1.30	
14	2.30	3.00	12.20	7.30	2.50	1.40	5.00	2.10	.50	1.00	1.20	
15	2.10	2.60	10.80	6.30	2.40	1.60	4.20	1.90	.40	1.20	1.00	
16	2.10	2.30	8.40	5.50	2.20	1.80	3.60	1.80	.40	1.30	1.00	
17	2.00	2.10	13.80	5.00	2.00	1.90	3.10	1.60	.40	1.60	.90	
18	2.00	2.10	12.70	4.70	1.90	2.00	3.30	1.50	.40	1.50	.90	
19	1.80	2.50	10.00	4.30	1.80	2.00	3.70	1.40	.30	1.40	.90	
20	1.60	2.20	8.10	3.90	1.70	1.80	4.40	1.30	.20	1.30	.80	
21	2.00	1.90	6.80	4.40	1.70	1.80	5.80	1.20	.20	1.30	.80	
22	5.30	2.20	6.00	3.50	1.70	1.70	6.80	1.40	.20	1.20	.80	
23	6.73	1.90	5.40	3.20	1.60	1.50	6.30	1.30	.20	1.10	.90	
24	4.50	1.80	5.00	2.90	1.60	1.40	5.70	1.10	.20	1.00	.90	
25	4.50	1.80	4.50	2.80	1.60	a.60	5.90	1.00	.50	1.00	1.00	
26	4.00	2.00	4.20	3.30	1.60	1.50	5.80	.90	.90	.90	1.10	
27	4.10	3.10	3.90	2.50	1.70	1.90	6.10	.80	2.30	.90	1.10	
28	4.00	10.80	3.70	2.40	1.80	2.80	5.50	.40	2.60	1.30	1.10	
29	3.90	.....	3.90	2.30	1.60	2.60	5.20	.50	2.80	1.20	1.00	
30	4.10	.....	5.60	2.50	1.50	4.30	4.50	.60	2.30	1.50	1.00	
31	4.50	.....	6.20	.....	1.40	.....	5.20	.50	.....	1.70	.....	

a Splash on dam.

WEST BRANCH OF SUSQUEHANNA RIVER AT ALLENWOOD, PA.

The West Branch of Susquehanna River rises in Cambria County, Pa., and flows in a general northeasterly direction, meeting the North Branch on the western border of Northumberland County and forming Susquehanna River.

Observations of height of water on the West Branch have been made by the weather bureau at Lockhaven, Pa., 47 miles above Allenwood. The drainage area is given as 3,740 square miles, and the width of river 1,125 feet. The gage is in two sections. The lower section is painted on the side wall of the canal lock, and the upper is on the highway bridge over the river. The elevation of the zero is 55.7 feet. The highest water was 18 feet, on June 1, 1889, and the anger line is at 10 feet.

Below the junction of the North and West Branches of Susquehanna River observations have been made of height of water by the Weather Bureau at Selins Grove, 45 miles above Harrisburg. The drainage area is given as 17,600 square miles. The river at this point is about 1 mile wide, including an island 400 feet wide. The gage is on the west abutment of a railroad bridge.

A gaging station was established on the West Branch by E. G. Paul on March 25, 1899, at Allenwood, Pa., 20 miles above the junction with the North Branch. Measurements are made from the public highway bridge, one-fourth of a mile east of the railroad station at Allenwood. The wire gauge is 42.15 feet from zero to the end of the weight, and is referred to a pine-board scale fastened to ironwork of the bridge and divided into feet and tenths. The initial point of soundings is at the end of the iron guard rail on the right bank. The channel is straight for one-half a mile above and below the station. The current is sluggish, but unobstructed. The banks are low and subject to overflow at time of high water. The bed of the stream is rocky and constant. The observer is Frank L. Allen, a farmer, living 200 feet from the gage. A bench mark was established on September 24, 1900. It consists of a copper bolt set in the capstone of the wing wall on the lower side of the west end of the bridge, and is 33.19 feet above datum of the gage.

This station was discontinued in April, 1902, the station at Williamsport taking its place.

The following discharge measurement was made during 1902, by Mr. Paul:

April, 21: Gage height, 4.4 feet: discharge, 9,896 second-feet.

Daily gage height, in feet, of West Branch of Susquehanna River at Allenwood, Pa.

Day.	Jan.	Feb.	Mar.	Apr.	Day.	Jan.	Feb.	Mar.	Apr.
1902.					1902.				
1	3.80	5.40	21.60	6.40	17	3.20	4.70	12.50	
2	3.80	5.20	19.40	6.50	18	3.10	4.70	10.00	
3	3.60	4.90	15.50	6.50	19	3.10	4.70	8.60	
4	3.60	4.90	11.50	6.40	20	3.10	4.70	7.40	
5	3.50	4.90	8.20	5.80	21	3.40	4.70	6.70	
6	3.50	4.90	6.80	.....	22	7.40	4.70	6.40	
7	3.50	4.80	6.40	.....	23	6.80	6.50	5.70	
8	3.50	4.80	5.50	.....	24	6.60	7.00	5.40	
9	3.40	4.80	4.90	.....	25	6.50	7.40	5.30	
10	3.40	4.80	6.40	.....	26	6.30	5.50	4.80	
11	3.40	4.80	7.60	.....	27	6.20	5.90	4.70	
12	3.30	4.70	8.40	.....	28	5.90	9.70	5.00	
13	3.20	4.70	10.00	.....	29	5.90	.....	5.00	
14	3.20	4.60	8.90	.....	30	5.80	.....	6.10	
15	3.20	4.50	8.60	.....	31	5.40	.....	6.30	
16	3.20	4.70	8.80	.....					

JUNIATA RIVER AT NEWPORT, PA.

Juniata River rises in Center County, Pa., and flows in a general southeasterly direction into Susquehanna River 15 miles above Harrisburg. Its drainage area is mountainous and for the most part covered with forest growth. The station was established at Newport, about 15 miles above its junction with the Susquehanna, on March 21, 1899, by E. G. Paul. It is at the covered wagon bridge, 800 feet east of the public square, Newport, Pa. Equipment consists of a standard chain-and-weight gage referred to a horizontal scale board graduated to feet and tenths inclosed in a lock box attached to the bridge timbers inside of the structure near the right bank. The length of the chain from the zero mark to the extreme end of the weight is 20 feet. The initial point of soundings is at the end of the woodwork of the bridge on the right bank. The channel is straight for half a mile above and below the station. The current is swift and unobstructed. The banks are high and not subject to overflow. The bed of the stream is rocky and the section constant. The observer is A. R. Bortel, a laborer living in Newport, Pa., about 800 feet from the gage. The following measurements were made by E. G. Paul during 1902.

April 19: Gage height, 5 feet; discharge, 6,779 second-feet.
September 17: Gage height, 2.84 feet; discharge, 734 second-feet.

Daily gage height, in feet, of Juniata River at Newport, Pa.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
.....	6.40	4.20	25.30	5.80	4.00	3.20	5.40	4.40	3.00	4.90	4.00	3.00
.....	5.60	4.20	19.50	5.70	3.80	3.20	6.30	4.00	3.00	4.90	3.80	3.60
.....	5.00	4.60	15.50	5.40	3.80	3.20	6.10	3.50	2.90	3.50	3.70	4.30
.....	5.40	3.90	12.00	5.30	3.90	3.20	6.40	4.00	2.90	3.50	3.60	5.30
.....	4.30	4.50	9.30	5.00	3.90	3.20	6.70	4.00	2.90	3.50	3.60	5.50
.....	4.20	3.60	7.10	5.00	3.90	3.20	5.60	4.00	2.90	4.00	3.50	4.90
.....	4.20	3.60	6.50	5.20	3.90	3.20	5.40	3.80	2.90	4.00	3.40	4.50
.....	4.20	3.70	6.00	14.65	3.90	3.10	5.00	3.80	2.90	3.80	3.30	4.50
.....	4.10	5.10	5.50	18.50	3.90	3.10	4.50	3.80	2.90	3.50	3.40	4.20
.....	4.10	5.80	6.20	18.50	3.90	3.10	4.80	4.00	3.10	3.40	3.40	4.40
.....	4.10	5.80	8.40	12.50	3.70	3.10	4.60	4.60	3.10	3.40	3.40	4.20
.....	4.00	5.70	9.50	10.00	3.50	3.10	4.00	3.90	3.00	4.60	3.30	5.30
.....	3.90	5.00	13.80	8.10	3.50	3.20	3.90	3.80	3.00	6.40	3.30	7.70
.....	3.90	4.50	14.10	7.00	3.30	3.30	3.90	3.60	2.90	6.00	3.30	4.80
.....	3.70	4.80	9.60	6.50	3.30	3.30	3.80	3.30	2.90	4.70	3.30	6.40
.....	3.50	5.10	9.00	5.50	3.30	4.30	3.60	3.40	2.90	4.40	3.20	5.80
.....	3.80	5.10	15.30	5.00	3.40	3.80	3.60	3.40	2.90	4.00	3.20	7.70
.....	3.80	5.10	12.50	5.00	3.40	3.90	3.60	3.30	2.90	3.80	3.20	7.00
.....	7.50	5.10	9.50	4.90	3.40	3.50	3.60	3.30	2.80	3.80	3.20	6.40
.....	4.00	4.90	8.00	4.70	3.40	3.30	3.50	3.20	2.90	3.50	3.20	5.70
.....	4.00	4.80	6.50	4.60	3.40	3.40	3.60	3.10	2.90	3.40	3.20	6.20
.....	9.50	4.80	6.00	4.50	3.40	3.10	3.70	3.20	2.80	3.30	3.20	9.50
.....	8.20	4.90	5.50	4.40	3.40	3.10	3.60	3.10	2.80	3.40	3.20	10.80
.....	6.20	4.40	5.50	4.30	3.40	3.10	3.50	3.30	2.80	3.30	3.20	8.60
.....	5.00	4.50	5.10	4.20	3.40	3.10	4.10	3.20	3.00	3.20	3.20	7.40
.....	4.60	9.00	5.00	4.10	3.40	4.00	3.80	3.20	3.30	3.20	3.30	6.30
.....	5.70	9.90	4.80	3.80	3.60	3.80	3.50	2.90	4.20	3.20	3.50	5.80
.....	7.50	14.90	4.50	3.80	3.40	3.90	3.50	4.30	3.60	3.80	3.70	5.30
.....	5.60	.....	4.25	4.00	3.30	3.90	3.60	4.70	3.50	5.70	3.80	4.80
.....	5.00	.....	5.80	4.10	3.30	4.70	4.20	3.30	3.50	5.00	3.80	4.70
.....	4.50	.....	6.00	.....	3.20	.....	4.20	2.90	.....	4.40	.....	4.70

Rating table for Juniata River at Newport, Pa., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.4	150	5.0	6,500	7.6	17,420	13.5	42,300
2.6	350	5.2	7,340	7.8	18,260	14.0	44,300
2.8	600	5.4	8,180	8.0	19,100	14.5	46,400
3.0	1,000	5.6	9,020	8.5	21,200	15.0	48,500
3.2	1,400	5.8	9,860	9.0	23,300	15.5	50,600
3.4	1,820	6.0	10,700	9.5	25,400	16.0	52,700
3.6	2,270	6.2	11,540	10.0	27,500	16.5	54,800
3.8	2,750	6.4	12,380	10.5	29,600	17.0	56,900
4.0	3,250	6.6	13,220	11.0	31,700	17.5	59,000
4.2	3,800	6.8	14,060	11.5	33,800	18.0	61,100
4.4	4,400	7.0	14,900	12.0	35,900		
4.6	5,020	7.2	15,740	12.5	38,000		
4.8	5,720	7.4	16,580	13.0	40,100		

Estimated monthly discharge of Juniata River at Newport, Pa.

[Drainage area, 3,476 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	25,400	2,040	7,096	2.04	2.3
February	48,080	2,270	8,486	2.44	2.5
March	91,760	3,800	23,604	6.79	7.8
April	63,200	2,750	13,753	3.96	4.4
May	3,250	1,400	2,194	.63	.7
June	5,360	1,200	1,929	.56	.6
July	13,640	2,040	4,801	1.38	1.5
August	5,360	800	2,409	.69	.8
September	3,800	600	1,092	.31	.3
October	12,380	1,400	3,743	1.08	1.2
November	3,250	1,400	1,867	.54	.6
December	30,860	2,270	10,094	2.90	3.3
The year	91,760	600	6,756	1.94	26.4

SUSQUEHANNA RIVER AT HARRISBURG, PA.

This station was established in 1890 by E. Mather, president of the Harrisburg water board.

Observations of the height of water since this time have been made

he pump house of the waterworks located in the western part of city of Harrisburg, Pa., this being about 55 miles below the junc- n of the north and west branches. A float is located in the pump ll connected with the river, which indicates the height of water on a painted scale. The datum is the low-water mark of 1804. servations are made by the engineer, C. M. Nagle, each morning fore starting the pumps. The record since 1890 has been furnished E. Mather, president of the Harrisburg water board. Measure- nts of discharge are made from the open iron bridge on Second eet. The initial point for soundings is the iron upright on the east d of the bridge. The stream is divided into two channels, with a ge island between. The channel above and below the station is aight for about 2,500 feet, the banks high, and the current of derate velocity. The first measurement was made on March 31, 97, by E. G. Paul. During 1902 Mr. Paul made the following easurements:

April 17: Gage height, 5.40 feet; discharge, 60,534 second-feet.
September 15: Gage height, 1.10 feet; discharge, 6,982 second-feet.

Daily gage height, in feet, of Susquehanna River at Harrisburg, Pa.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	5.25	3.58	20.33	6.25	2.75	1.75	3.58	5.83	1.25	4.83	5.50	2.41
	4.75	3.66	23.91	5.58	2.83	1.75	6.16	5.33	1.25	6.00	4.75	2.41
	4.25	3.50	23.33	5.33	2.83	1.66	7.33	5.50	1.25	5.91	4.50	2.58
	3.83	3.25	21.41	5.00	2.66	1.66	6.66	6.25	1.25	5.66	4.00	3.33
	3.00	2.41	16.33	4.75	2.66	1.66	7.83	5.50	1.16	4.66	3.50	3.75
	3.00	2.00	12.25	4.50	2.83	1.66	7.50	4.83	1.08	4.66	3.50	3.25
	3.00	6.08	9.50	4.50	2.75	1.50	6.83	4.50	1.00	4.66	3.25	3.50
	2.83	5.25	7.00	4.50	2.66	1.25	7.33	4.00	0.91	4.41	3.08	3.41
	2.75	5.00	5.25	9.00	2.66	1.50	8.50	3.58	0.91	3.83	2.91	3.41
	3.00	5.08	5.00	14.66	2.66	1.58	7.16	3.25	0.91	3.83	2.75	3.16
	2.91	5.33	6.66	14.16	2.66	1.50	6.16	3.50	0.91	3.50	2.66	3.00
	2.66	5.16	8.33	11.58	2.50	1.50	6.16	3.58	1.25	3.58	2.41	3.00
	2.58	4.83	10.91	10.91	2.41	1.50	6.25	3.25	1.25	4.75	2.41	3.83
	2.25	4.41	13.41	8.16	2.33	1.50	5.50	3.08	1.08	4.83	2.33	3.66
	2.25	4.41	13.58	7.08	2.25	1.75	4.58	2.83	1.16	3.75	2.33	4.00
	2.25	4.25	12.00	6.41	2.16	1.75	4.00	2.75	1.08	3.91	2.25	4.00
	2.16	4.08	12.16	5.66	2.16	2.25	3.50	2.50	1.08	3.75	2.16	5.33
	2.00	3.83	15.00	5.08	2.00	2.41	3.25	2.50	1.00	3.16	2.16	8.58
	2.00	3.75	13.66	4.75	1.83	2.41	3.25	2.16	1.00	3.33	2.16	8.33
	2.16	3.75	11.33	4.41	1.83	2.33	3.16	2.00	1.00	3.00	1.91	7.66
	2.16	3.75	9.50	4.08	1.75	2.16	3.33	2.00	1.00	2.91	1.83	7.16
	5.16	4.00	6.00	3.83	1.75	2.16	4.33	1.91	0.91	2.66	1.75	8.50
	10.00	4.00	5.50	3.50	1.83	2.16	8.08	1.91	0.83	2.58	1.75	12.50
	6.75	4.08	5.33	3.41	1.66	2.00	8.00	1.75	0.83	2.41	1.66	12.66
	6.50	4.16	5.33	3.25	1.66	2.00	7.25	1.75	0.83	2.25	1.66	11.50
	5.41	6.41	4.66	3.00	1.66	2.00	7.75	1.58	1.66	2.41	1.91	8.25
	5.08	9.41	3.66	2.91	1.66	2.16	8.08	1.58	3.75	2.33	2.00	7.25
	5.33	9.66	3.66	2.75	1.66	2.41	6.83	1.50	5.16	2.33	2.25	6.16
	5.33	.....	4.41	2.75	1.66	2.41	5.83	1.41	4.33	3.66	2.33	5.58
	4.83	.....	4.41	2.75	1.66	3.00	6.16	1.25	4.33	5.66	2.41	4.83
	3.91	.....	5.33	.....	1.75	.....	6.16	1.25	.....	6.00	.....	4.58

Rating table for Susquehanna River at Harrisburg, Pa., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
0.0	2,500	3.4	27,925	6.8	83,970	13.5	303.90
.2	3,230	3.6	30,300	7.0	87,550	14.0	212.50
.4	4,020	3.8	32,800	7.2	91,130	14.5	221.90
.6	4,820	4.0	35,400	7.4	94,710	15.0	230.70
.8	5,720	4.2	38,100	7.6	98,290	15.5	239.70
1.0	6,880	4.4	41,100	7.8	101,870	16.0	248.60
1.2	8,150	4.6	44,590	8.0	105,450	16.5	257.60
1.4	9,450	4.8	48,170	8.5	114,400	17.0	266.50
1.6	10,750	5.0	51,750	9.0	123,350	17.5	275.30
1.8	12,300	5.2	55,330	9.5	132,300	18.0	284.40
2.0	13,900	5.4	58,910	10.0	141,250	18.5	293.40
2.2	15,500	5.6	62,490	10.5	150,200	19.0	302.30
2.4	17,300	5.8	66,070	11.0	159,150	19.5	311.30
2.6	19,300	6.0	69,650	11.5	168,100	20.0	320.20
2.8	21,300	6.2	73,230	12.0	177,050	20.5	329.30
3.0	23,400	6.4	76,810	12.5	186,000	21.0	338.10
3.2	25,625	6.6	80,390	13.0	194,950	21.5	347.10

Estimated monthly discharge of Susquehanna River at Harrisburg, Pa.

[Drainage area, 24,030 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
ıuary	141,250	13,900	37,243	1.55	1.79
bruary	134,985	13,900	47,035	1.96	2.04
ırch	390,060	30,900	146,782	6.11	7.04
ril	224,485	20,800	68,458	2.85	3.18
ıy	21,800	11,125	15,806	.66	.76
ne	23,400	8,475	13,314	.55	.61
ly	114,400	25,050	71,078	2.96	3.41
ıgust	74,125	8,475	21,241	1.13	1.30
ptember	54,435	5,990	11,951	.50	.56
tober	69,650	15,950	36,579	1.52	1.75
›vember	60,700	11,125	21,216	.88	.98
›cember	188,685	17,300	64,016	2.66	3.07
The year	390,060	5,990	46,727	1.94	26.49

PATAPSCO RIVER AT WOODSTOCK, MD.

This river rises in the north-central part of Maryland, flows in a ›utheasterly direction between Baltimore and Howard counties, and npties into Chesapeake Bay 13 miles below Baltimore. Its drainage ısin is a hilly country largely under cultivation. A station was ıtablished at Woodstock August 6, 1896, by E. G. Paul. The drain-ge area is 251 square miles. Measurements are made from the ›unty bridge on the road from Woodstock to Granite, Md., 1½ miles elow the junction with the North Branch, as shown on the Ellicott tlas sheet. The scale is a board graduated to feet and tenths with nall nails, and fastened to the floor timber of the bridge. The ench mark is a United States Geological Survey standard copper olt, set in the face of the retaining wall of the entrance to the college rounds at the north end of the bridge. It is 22.06 feet above gage atum. The bridge was repaired on January 20–25, 1899, and the age destroyed. A new gage was established on January 30, 1899, nd referred to the same bench mark. The channel is rough and ocky. The banks are high and not subject to overflow. At a time f extreme high water the channel is liable to changes. The observer s David Donovan, a storekeeper at Woodstock, Md.

The following discharge measurement was made during 1902 by E. G. Paul:

September 4: Gage height 3.70 feet; discharge, 153 second-feet.

Daily gage height, in feet, of Patapsco River at Woodstock, Md.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	4.00	4.90	5.35	4.65	4.50	3.85	4.30	3.85	3.65	6.50	3.6	[illegible]
2	4.00	4.95	5.75	4.60	4.45	3.75	4.05	3.80	3.60	4.95	3.5	[illegible]
3	4.00	4.70	5.50	4.55	4.45	3.75	3.95	3.75	3.65	4.40	3.6	[illegible]
4	4.15	4.65	5.15	4.45	4.45	3.80	3.95	4.10	3.75	4.10	3.6	[illegible]
5	4.15	4.55	5.15	4.50	4.35	3.70	3.85	3.80	3.45	4.05	3.5	[illegible]
6	4.10	4.45	5.10	4.55	4.30	3.70	3.80	4.70	3.50	3.95	3.5	[illegible]
7	4.20	4.35	5.00	4.60	4.30	3.65	3.70	4.85	3.50	3.85	3.6	[illegible]
8	4.25	4.30	4.95	7.20	4.30	4.85	3.65	4.80	3.50	3.85	3.5	[illegible]
9	4.30	4.35	5.15	5.50	4.30	4.05	3.65	4.60	4.85	3.75	3.8	[illegible]
10	4.20	4.35	5.30	5.15	4.30	4.00	3.45	4.30	4.05	3.75	3.8	[illegible]
11	4.20	4.25	5.25	4.95	4.25	3.90	3.70	4.05	3.60	3.85	3.8	[illegible]
12	4.20	4.25	5.20	4.85	4.30	3.85	3.60	3.75	3.45	3.85	3.8	[illegible]
13	4.15	4.35	5.40	4.85	4.30	3.85	3.70	3.85	3.45	3.85	3.8	[illegible]
14	4.00	4.70	5.20	4.80	4.30	3.90	3.80	3.70	3.50	3.90	3.8	[illegible]
15	4.15	4.55	4.80	4.75	4.25	3.80	3.80	3.70	3.45	3.80	3.7	[illegible]
16	4.10	4.60	5.10	4.75	4.25	4.15	3.70	3.75	3.35	3.75	3.7	[illegible]
17	4.10	4.55	4.95	4.65	4.20	4.15	3.60	3.60	3.45	3.85	3.8	[illegible]
18	4.10	4.60	4.90	4.60	4.15	4.05	3.80	3.60	3.45	3.85	3.8	[illegible]
19	4.10	4.75	4.75	4.60	4.10	4.10	3.65	3.70	3.40	3.90	3.8	[illegible]
20	4.05	4.55	4.70	4.55	4.10	4.00	3.65	3.65	3.50	3.80	3.7	[illegible]
21	4.50	5.70	4.75	4.50	4.05	4.50	3.70	3.70	3.45	3.75	3.7	[illegible]
22	6.50	6.50	4.55	4.45	4.10	4.20	3.80	3.70	3.55	3.75	3.8	[illegible]
23	4.40	5.70	4.60	4.45	4.10	4.05	3.85	3.70	3.55	3.85	3.8	[illegible]
24	4.25	4.95	4.55	4.45	4.05	3.90	3.85	3.60	3.50	3.70	3.9	[illegible]
25	4.20	8.60	4.50	4.40	4.00	4.25	3.70	3.65	3.90	3.75	4.7	[illegible]
26	4.85	5.75	4.45	4.40	3.95	5.45	3.80	3.65	5.50	3.75	4.7	[illegible]
27	5.75	13.50	4.55	4.45	3.90	4.70	3.65	3.60	4.50	3.80	4.0	[illegible]
28	4.90	10.40	4.55	4.40	4.10	4.35	3.70	3.80	3.85	3.75	4.0	[illegible]
29	4.40	.....	4.75	4.40	4.00	3.95	3.75	3.80	3.65	3.85	4.0	[illegible]
30	4.20	.....	4.60	4.95	3.95	4.70	3.95	3.70	3.60	3.85	3.9	[illegible]
31	4.05	.....	4.55	.....	3.90	.....	4.25	3.70	.....	3.80	.....	[illegible]

Rating table for Patapsco River at Woodstock, Md., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.0	50	4.8	830	6.6	2,615	9.0	5,07[illegible]
3.2	83	5.0	1,000	6.8	2,820	9.5	5,58[illegible]
3.4	122	5.2	1,200	7.0	3,025	10.0	6,1[illegible]
3.6	173	5.4	1,400	7.2	3,229	10.5	6,6[illegible]
3.8	235	5.6	1,600	7.4	3,435	11.0	7,1[illegible]
4.0	310	5.8	1,800	7.6	3,640	11.5	7,6[illegible]
4.2	400	6.0	2,000	7.8	3,844	12.0	8,1[illegible]
4.4	520	6.2	2,205	8.0	4,050		
4.6	670	6.4	2,410	8.5	4,562		

Estimated monthly discharge of Patapsco River at Woodstock, Md.

[Drainage area, 251 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
anuary	2,307	235	432	1.72	1.98
ebruary	9,483	332	1,348	5.38	5.60
larch	1,550	425	797	3.18	3.67
pril	3,025	400	649	2.58	2.88
lay	450	200	313	1.24	1.43
une	1,250	135	305	1.22	1.36
uly	355	91	174	.69	.80
ugust	710	122	225	.90	1.04
eptember	1,500	111	245	.98	1.09
ctober	2,512	200	351	1.40	1.61
November	750	200	292	1.16	1.29
December	1,200	425	651	2.59	2.99
The year	9,483	91	482	1.92	25.74

POTOMAC RIVER DRAINAGE BASIN.

Potomac River is formed by the junction of the North and South branches, about 15 miles below Cumberland, Md. Regular gaging stations have been maintained on the North Branch at Piedmont, W. Va., on the South Branch near Springfield, W. Va., on Antietam Creek near Sharpsburg, Md., on the North Branch of Shenandoah River near Riverton, Va., on the South Branch of Shenandoah River near Front Royal, Va., on Shenandoah River at Millville, W. Va., on Potomac River at Point of Rocks, Md., and on Monocacy River near Frederick, Md.

NORTH BRANCH OF POTOMAC RIVER AT PIEDMONT, W. VA.

This stream rises in the western part of West Virginia and flows in a northeasterly direction, forming the boundary between Maryland and West Virginia. At a point about 15 miles below Cumberland it is joined by the South Branch, forming the Potomac River. The drainage area is mapped on Piedmont, St. George, Accident, Grantsville, and Frostburg atlas sheets. Systematic measurements of discharge have been made at Piedmont, W. Va. This station, established June 27, 1899, by E. G. Paul, is located at the iron highway bridge connecting Luke, Md., with Piedmont, W. Va. The equipment

consists of a standard chain-and-weight gage, referred to a horizontal scale board graduated to feet and tenths, inclosed in lock-box secured by bolts to the hand rail on the lower side of the bridge. The length of the chain from the zero to the extreme end of the weight is [illegible] feet. The channel is straight for an eighth of a mile above and below the station. The current is swift and unobstructed. The right bank is high and rocky, but the left bank is low and liable to overflow. The bed of the stream is rocky and permanent in section. The observer is Charles W. Beck, a bookkeeper at Piedmont, W. Va.

The following discharge measurement were made during 1902, by E. G. Paul:

August 19: Gage height, 2.14 feet; discharge, 50 second-feet.

Daily gage height, in feet, of North Branch of Potomac River at Piedmont, W. Va.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	4.45	3.80	8.05	4.90	3.55	3.30	4.75	2.85	1.90	3.30	2.40	[illegible]
2	4.00	3.60	7.10	4.65	3.40	3.20	3.80	2.70	1.90	3.35	2.50	[illegible]
3	4.30	3.50	6.20	4.40	3.70	3.10	3.35	2.60	1.90	2.85	2.50	[illegible]
4	3.80	3.20	5.40	4.70	3.70	3.00	3.20	2.50	2.00	2.70	2.40	[illegible]
5	3.65	3.40	4.95	5.05	3.55	3.00	3.10	2.50	2.20	2.90	2.40	[illegible]
6	3.60	3.50	4.50	5.95	3.45	2.85	2.95	2.50	2.35	2.90	2.40	[illegible]
7	3.60	3.50	4.20	6.20	3.50	2.80	2.80	2.50	2.20	2.85	2.40	[illegible]
8	3.60	3.40	4.20	6.45	3.40	2.85	3.05	2.40	2.10	2.60	2.50	[illegible]
9	3.45	3.30	4.65	5.85	3.30	2.95	3.20	2.40	2.00	2.50	2.50	[illegible]
10	3.45	3.20	4.95	5.70	3.20	2.85	2.95	2.45	2.00	2.40	2.50	[illegible]
11	3.40	3.15	5.65	6.20	3.40	2.70	3.20	2.50	2.00	2.40	2.50	[illegible]
12	3.30	3.15	6.85	7.05	3.25	2.70	3.05	2.40	2.00	3.25	2.50	[illegible]
13	3.10	3.10	8.10	6.25	3.20	2.60	2.80	2.35	1.90	3.70	2.50	[illegible]
14	3.20	3.05	6.60	5.80	3.15	3.10	2.70	2.30	1.90	3.35	2.50	[illegible]
15	3.20	3.10	5.85	5.55	3.10	2.90	2.60	2.25	1.90	3.15	2.40	[illegible]
16	3.10	3.00	5.85	5.25	3.10	2.80	2.50	2.20	1.90	2.95	2.40	[illegible]
17	3.05	3.00	6.75	5.10	3.00	2.70	2.45	2.20	1.90	2.70	2.45	[illegible]
18	2.90	3.00	5.65	4.95	3.00	2.60	2.40	2.20	1.90	2.70	2.50	[illegible]
19	3.00	3.00	4.95	4.55	2.90	2.50	2.40	2.15	1.90	2.70	2.50	[illegible]
20	2.90	2.85	4.60	4.40	3.45	2.50	2.55	2.10	1.90	2.60	2.50	[illegible]
21	2.90	2.80	4.45	4.25	3.75	2.60	2.60	2.15	1.90	2.50	2.50	[illegible]
22	2.90	2.80	4.50	4.15	3.45	2.90	2.50	2.50	2.00	2.40	2.50	[illegible]
23	2.90	3.00	4.50	4.25	3.40	2.70	2.40	2.40	2.00	2.40	2.50	[illegible]
24	3.00	3.05	4.50	4.15	3.30	2.50	2.40	2.30	2.00	2.40	2.50	[illegible]
25	3.00	3.35	4.45	3.80	3.30	2.40	2.30	2.30	2.00	2.40	2.75	[illegible]
26	3.30	6.55	4.25	3.70	3.60	2.80	2.30	2.10	2.20	2.40	5.45	[illegible]
27	5.73	6.05	4.15	3.65	4.10	3.00	2.30	2.10	2.20	2.40	4.30	[illegible]
28	5.00	10.50	4.20	3.55	4.00	2.70	2.30	2.00	2.65	(a)	3.95	[illegible]
29	4.65	.....	5.50	3.60	3.80	2.60	2.30	1.90	2.40	(a)	3.60	[illegible]
30	4.10	.....	5.30	3.70	3.60	2.75	2.20	1.90	2.45	2.80	3.30	[illegible]
31	4.05	.....	5.25	.....	3.35	.....	2.30	1.90	.....	2.70	.....	[illegible]

a Gage chain broken.

ating table for North Branch Potomac River at Piedmont, W. Va., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.8	34	3.6	640	5.4	2,040	7.2	3,480
2.0	77	3.8	775	5.6	2,200	7.4	3,640
2.2	124	4.0	920	5.8	2,360	7.6	3,800
2.4	175	4.2	1,080	6.0	2,520	7.8	3,960
2.6	230	4.4	1,240	6.2	2,680	8.0	4,120
2.8	289	4.6	1,400	6.4	2,840	8.5	4,520
3.0	352	4.8	1,560	6.6	3,000	9.0	4,920
3.2	430	5.0	1,720	6.8	3,160		
3.4	525	5.2	1,880	7.0	3,320		

Estimated monthly discharge of North Branch Potomac River at Piedmont, W. Va.

[Drainage area, 409 square miles.]

Month.	Discharge in second-feet			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
anuary	2,304	320	688	1.68	1.94
ebruary	6,120	289	809	1.98	2.06
[arch	4,160	1,040	2,008	4.91	5.66
pril	3,360	610	1,666	4.07	4.54
[ay	1,000	320	553	1.35	1.56
une	475	175	292	.71	.79
uly	1,520	124	313	.77	.89
ugust	305	55	153	.37	.43
eptember	245	55	91	.22	.25
)ctober	705	175	288	.70	.81
Jovember	2,080	175	347	.85	.95
)ecember	3,800	552	1,516	3.71	4.28
The year	6,120	55	727	1.78	24.16

SOUTH BRANCH OF POTOMAC RIVER AT SPRINGFIELD, W. VA.

This stream rises in Highland County, W. Va., and flows in a northeasterly direction, joining the North Branch of Potomac River about 15 miles below Cumberland, Md., forming Potomac River. The drainage area of the South Branch consists of long, narrow mountain valleys, sparsely settled and little cultivated, being for the greater part covered with timber. The region being free from manufacturing industries and mining operations, no pollution of the water occurs. A gaging station was established at the railroad bridge 2 miles south of Springfield, W. Va., in April, 1894, by Cyrus C. Babb, but was discontinued in 1896 for want of an observer. The present station, established June 26, 1899, by E. G. Paul, is located on the iron highway bridge, one-fourth of a mile from Graces Station and 1 mile from Springfield. The wire gage is 39.4 feet from the zero to the extreme end of the weight and is referred to a scale graduated to feet and tenths on the guard rail on the upper side of the bridge 80 feet from the abutment on the left bank. The channel of the stream at this point is curved and the current too sluggish to make satisfactory discharge measurements, and they are therefore made from the railroad bridge over the stream 1 mile above. The observer is John E. Grace, of Springfield, W. Va.

On February 2, 1902, the bridge and gage were carried away by the ice, and the station was discontinued.

ANTIETAM CREEK NEAR SHARPSBURG, MD.

This stream rises in the western part of Maryland and flows in a southerly direction, entering the Potomac 10 miles above Harpers Ferry. Its drainage area is mostly of a hilly character and largely cultivated. A station was established at Myers Mill, 1 mile east of Sharpsburg, Md., on the road to Keedysville, Md., on June 24, 1897, by Arthur P. Davis. The measurements are made from a three-fourths inch iron cable with 85-foot span supported by large trees on either side of the stream. The gage is a post driven into the gravel of the stream bed and bolted to an overhanging tree. The initial point for soundings is on the left bank. The channel both above and below the station is straight for 300 feet. The right bank is low and liable to overflow. The left bank is high and rocky. The current is of moderate velocity and the flow unobstructed.

During 1902 the following measurement was made by E. G. Paul:

September 1: Gage height, 1.7 feet; discharge, 126 second-feet.

Daily gage height, in feet, of Antietam Creek near Sharpsburg, Md.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	2.90	2.40	7.00	2.90	2.60	2.10	2.20	2.60	1.70	1.70	1.60	1.80
	2.70	2.40	5.05	2.90	2.50	2.20	2.10	2.40	1.60	1.80	1.70	2.40
	2.70	2.60	4.60	2.80	2.50	2.20	2.10	1.80	1.60	1.60	1.70	4.05
	2.50	2.50	3.90	2.80	2.50	2.20	2.00	1.80	1.70	1.60	1.60	3.60
	2.40	2.40	4.00	2.80	2.50	2.10	2.00	1.90	1.60	2.30	1.60	2.60
	2.40	2.30	3.60	2.70	2.40	2.10	1.90	1.90	1.50	2.10	1.70	2.50
	2.30	2.20	3.50	2.90	2.40	2.10	2.30	1.90	1.50	1.90	1.70	2.30
	2.30	2.10	3.50	3.90	2.40	2.00	2.70	1.70	1.40	1.70	1.70	2.10
	2.30	2.10	3.70	6.45	2.30	2.00	2.70	1.70	1.60	1.70	1.70	1.80
	2.30	2.30	4.20	4.45	2.30	2.00	3.50	1.60	1.60	1.60	1.70	1.90
	2.30	2.40	4.40	3.90	2.40	2.00	2.00	1.80	1.70	1.80	1.60	2.00
	2.20	2.20	4.40	3.60	2.30	2.10	2.00	1.80	1.60	1.80	1.60	2.40
	2.20	2.30	4.80	3.50	2.30	2.20	1.80	1.70	1.70	2.10	1.60	2.80
	2.20	2.20	4.70	3.30	2.30	2.20	1.80	1.60	1.50	1.90	1.50	2.70
	2.10	2.20	3.90	3.20	2.30	2.20	1.80	1.60	1.40	1.80	1.50	2.70
	2.10	2.00	3.70	3.10	2.20	2.30	1.70	1.60	1.60	1.70	1.60	2.80
	2.10	2.20	5.10	3.10	2.20	2.40	1.70	1.40	1.60	1.70	1.70	4.10
	2.10	2.10	4.20	3.00	2.20	2.40	1.70	1.40	1.60	1.70	1.70	3.80
	2.10	1.90	3.70	2.90	2.90	2.20	2.40	1.50	1.60	1.60	1.60	3.80
	2.10	2.00	3.50	2.90	2.40	2.30	2.70	1.50	1.50	1.80	1.60	3.50
	3.80	3.15	3.60	2.80	2.30	2.30	1.80	2.00	1.60	1.70	1.60	3.60
	4.25	4.70	3.40	2.80	2.30	2.00	1.80	2.00	1.40	1.70	1.50	3.80
	2.70	3.60	3.40	2.80	2.20	2.00	1.70	1.90	1.50	1.80	1.50	3.60
	2.40	3.50	3.40	2.70	2.20	2.00	1.70	1.70	1.70	1.70	1.50	3.10
	2.40	6.20	3.10	2.70	2.40	1.90	1.90	1.50	1.70	1.70	1.60	3.10
	2.30	10.00	3.00	2.60	2.60	2.20	1.80	1.50	1.80	1.70	1.80	2.80
	4.25	5.15	3.00	2.60	2.20	2.20	1.80	1.50	2.30	1.70	2.20	2.90
	3.20	7.45	2.90	2.60	2.30	2.20	1.70	1.60	1.60	1.70	2.10	3.00
	2.70	.....	3.40	2.60	2.20	2.20	1.70	1.50	1.60	2.10	1.80	3.20
	2.60	.....	3.10	2.70	2.20	2.40	1.90	1.50	1.50	1.80	2.30	3.10
	2.40	.....	3.00	.....	2.20	.....	2.55	.....	.....	1.60	.....	3.10

Rating table for Antietam Creek near Sharpsburg, Md., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.2	38	2.6	416	4.0	1,215	5.4	2,013
1.4	60	2.8	485	4.2	1,329	5.6	2,127
1.6	95	3.0	560	4.4	1,443	5.8	2,241
1.8	154	3.2	665	4.6	1,557	6.0	2,355
2.0	217	3.4	775	4.8	1,671		
2.2	281	3.6	887	5.0	1,785		
2.4	348	3.8	1,001	5.2	1,899		

Estimated monthly discharge of Antietam Creek near Sharpsburg, Md.

[Drainage area, 236 square miles.]

Month.	Discharge in second-feet.			Run-off	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	1,357	249	434	1.48	1.7
February	4,635	185	787	2.68	2.9
March	2,925	520	1,094	3.73	4.3
April	2,612	416	668	2.28	2.5
May	520	281	333	1.14	1.3
June	348	185	268	.92	1.0
July	830	123	238	.81	.9
August	416	60	139	.47	.5
September	314	60	102	.35	.4
October	314	95	148	.51	.6
November	314	75	123	.42	.5
December	1,273	154	591	2.02	2.3
The year	4,635	60	410	1.40	18.9

NORTH BRANCH OF SHENANDOAH RIVER AT RIVERTON, VA.

This stream rises in Rockingham County, Va., and flows in a northeasterly direction, joining the South Branch of the Shenandoah at Riverton, Va. The station was established at Riverton by A. P. Davis, June 26, 1899. Measurements were made from an iron-wire cable about 260 feet in span stretched across the river on timber supports 2 miles northwest of Riverton. The station is most easily reached by a private conveyance from Front Royal, Va. The gage is a vertical timber, graduated to feet and tenths, bolted to a large sycamore tree on the right bank of the stream. The initial point of soundings is on the right bank. The channel is straight above and below the station for about 600 feet. The banks are low and liable to overflow in time of high water. Bed of stream is rocky and constant. The observer is L. W. Burke, a farmer, Riverton, Va. Two observations of river height are taken daily. On September 10, 1902, the gage was moved to the left bank of the river and its datum changed 1 foot, causing all readings to be increased by 1 foot.

The gage at this station washed out in the flood of February 25, 1902, and the station was temporarily abandoned until August 17, 1902, when it was reestablished by Mr. Paul, the zero of the new gage being at the same elevation as the zero of the former gage.

The following discharge measurement was made during 1902 by Mr. ıul:

August 16: Gage height, 4.2 feet; discharge, 256 second-feet.

ıily gage height, in feet, of North Branch of Shenandoah River near Riverton, Va.

Day.	Jan.	Feb.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.							
	7.05	4.90	(a)	4.05	4.30	4.10	5.45
	6.20	7.88	.....	4.05	4.20	4.15	5.75
	5.75	4.80	.....	4.10	4.20	4.10	5.85
	5.40	5.20	.....	4.35	4.20	4.10	5.90
	5.00	5.50	.....	4.10	4.20	4.15	5.80
	4.90	5.50	.....	4.05	4.20	4.20	5.80
	4.85	5.50	.....	4.00	4.90	4.20	5.55
	4.80	5.50	.....	4.05	4.20	4.10	5.50
	4.70	5.50	.....	4.05	4.15	4.10	5.30
	4.68	5.50	.....	4.10	4.10	4.10	5.15
	4.55	5.50	.....	4.10	4.15	4.00	5.05
	4.50	5.50	.....	4.10	4.25	4.10	5.35
	4.60	5.50	.....	4.05	4.30	4.10	5.25
	4.55	5.50	.....	4.00	4.60	4.10	6.60
	4.60	5.50	.....	4.00	4.35	4.10	6.30
	4.55	5.50	.....	3.90	4.30	4.10	5.85
	4.48	5.50	4.20	4.00	4.25	4.10	8.15
	4.35	5.50	4.10	4.00	4.20	4.10	7.65
	4.28	5.50	4.20	4.00	4.20	4.20	7.10
	4.20	5.50	4.20	4.00	4.15	4.20	5.75
	4.30	5.50	4.20	4.00	4.10	4.20	5.50
	5.40	5.50	4.20	4.05	4.10	4.20	5.45
	5.15	(a)	4.20	4.05	4.10	4.20	5.25
	4.75	.....	4.20	4.10	4.10	4.20	5.20
	4.60	.....	4.20	4.10	4.10	4.35	5.00
	4.75	.....	4.20	4.10	4.10	5.00	4.95
	5.00	.....	4.10	4.10	4.10	4.95	4.85
	6.15	.....	4.10	4.05	4.20	5.20	4.90
	5.50	.....	4.15	4.15	4.20	5.10	5.00
	5.05	.....	4.10	4.20	4.20	5.00	4.85
	4.95	.....	4.10	.....	4.20	.....	4.70

a Gage washed out Feb. 22, 1902; reestablished Aug. 17, 1902.

SOUTH BRANCH OF SHENANDOAH RIVER AT FRONT ROYAL, VA.

This stream rises in Augusta County, Va., and flows in a northeasterly direction, joining the North Branch of the Shenandoah at Riverton to form Shenandoah River. A station was established on the South Branch by A. P. Davis, June 26, 1899. The measurements of flow are made from an iron wire cable, 300 feet in span, stretched across the stream 3 miles southwest of Front Royal, Va. The gage is a vertical timber divided into feet and tenths and bolted to the trunk of a tree on the left bank of the stream. The initial point for sounding is on the left bank. The channel is straight 600 feet above and below the station, and the current sluggish. The left

bank is low and liable to overflow. The bed of the stream is rocky in part, with patches of sand, somewhat shifting. The observer is Miss Brentie Johnson, Front Royal, Va.

The following discharge measurement was made during 1902 by Mr. Paul.

August 15: Gage height, 4.2 feet; discharge, 527 second-feet.

Daily gage height, in feet, of South Branch of Shenandoah River at Front Royal, Va.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	Dec
1902.												
1	9.50	6.10	23.50	6.55	5.40	4.90	4.60	4.40	4.00	5.00	4.25	5.4
2	9.15	5.25	13.00	6.45	5.35	4.80	4.55	4.40	3.95	4.30	4.25	6.0
3	8.30	6.70	9.90	6.25	5.30	4.75	4.50	4.60	3.90	6.00	4.40	7.0
4	7.70	6.05	9.50	6.15	6.50	4.70	4.45	4.60	3.90	5.10	4.50	7.2
5	8.40	6.60	8.90	5.95	6.35	4.60	4.40	4.60	3.85	5.00	4.30	7.6
6	8.15	5.90	8.40	7.40	6.15	4.55	4.50	4.50	3.80	4.30	4.30	7.6
7	8.00	5.70	7.95	7.25	5.85	4.50	4.45	4.50	3.80	4.30	4.20	6.6
8	7.75	6.90	7.50	7.70	5.65	4.90	4.40	4.40	4.00	4.20	4.30	6.2
9	7.55	5.90	9.10	9.10	5.50	4.90	4.40	4.30	4.20	4.10	4.30	6.0
10	7.30	5.70	10.50	10.50	5.35	4.85	4.30	4.40	4.10	4.55	4.20	6.5
11	6.55	5.90	13.25	10.50	5.50	4.80	4.30	4.35	4.10	4.90	4.25	7.6
12	6.00	6.10	11.85	9.60	5.45	4.80	4.20	4.30	4.00	4.90	4.35	7.7
13	5.90	6.10	10.10	6.90	5.40	4.70	4.60	4.30	4.00	5.30	4.35	6.1
14	5.80	5.75	8.50	6.75	5.40	4.60	4.60	4.20	4.00	5.65	4.25	6.1
15	5.75	5.45	8.10	6.60	5.30	4.80	4.50	4.20	4.00	5.35	4.10	6.0
16	5.65	5.50	8.80	6.45	5.30	4.80	4.50	4.15	4.00	5.00	4.25	6.5
17	5.55	5.40	8.45	6.25	5.30	4.70	4.45	4.25	4.00	4.65	4.60	6.9
18	5.50	5.35	8.20	6.15	5.40	4.65	4.40	4.30	4.10	4.45	4.50	6.7
19	5.50	5.30	7.80	6.00	5.40	4.60	4.35	4.35	3.90	4.40	4.50	7.0
20	5.45	5.25	7.35	6.20	5.40	4.55	4.50	4.35	3.85	4.40	4.45	6.6
21	5.35	5.20	6.75	6.15	5.30	4.45	4.50	4.30	3.80	4.35	4.40	6.3
22	6.30	7.45	6.45	6.00	5.25	4.80	4.40	4.20	3.80	4.30	4.35	6.9
23	5.75	6.20	7.90	5.80	5.20	4.75	4.40	4.10	4.00	4.30	4.30	6.2
24	5.30	7.35	7.90	5.70	5.10	4.70	4.30	4.20	4.10	4.30	4.35	6.5
25	5.30	11.00	7.80	5.55	5.20	4.60	4.20	4.15	4.15	4.35	4.40	5.9
26	5.25	15.00	7.70	5.50	5.10	4.50	4.20	4.10	4.20	4.35	4.30	5.6
27	6.40	20.00	7.60	5.60	5.10	4.50	5.50	4.10	4.20	4.40	5.75	5.5
28	7.30	14.50	7.45	5.55	5.00	4.40	5.35	4.00	4.20	4.50	6.25	5.5
29	8.55	.....	6.55	5.45	4.90	4.70	5.05	4.00	6.00	4.35	5.75	5.1
30	6.70	.....	6.70	5.40	4.80	4.70	4.75	4.00	5.55	4.30	5.30	5.4
31	5.45	.....	6.65	.....	4.75	.....	4.55	4.00	.....	4.30	.....	5.3

ng table for South Branch of Shenandoah River at Front Royal, Va., for 1902.

·age ·ight.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
·eet.	Second-feet.	Feet.	Second-feet.	Feet.	Second-feet.	Feet.	Second-feet.
4.0	360	6.4	3,100	10.0	9,580	16.0	20,380
4.2	470	6.6	3,460	10.5	10,480	16.5	21,280
4.4	605	6.8	3,820	11.0	11,380	17.0	22,180
4.6	750	7.0	4,180	11.5	12,280	17.5	23,080
4.8	915	7.2	4,540	12.0	13,180	18.0	23,980
5.0	1,100	7.4	4,900	12.5	14,080	18.5	24,880
5.2	1,300	7.6	5,260	13.0	14,980	19.0	25,780
5.4	1,520	7.8	5,620	13.5	15,880	19.5	26,680
5.6	1,760	8.0	5,980	14.0	16,780	20.0	27,580
5.8	2,050	8.5	6,880	14.5	17,680		
6.0	2,380	9.0	7,780	15.0	18,580		
6.2	2,740	9.5	8,680	15.5	19,480		

imated monthly discharge of South Branch Shenandoah River at Front Royal, Va.

[Drainage area, 1,569 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
nuary	8,680	1,355	3,676	2.34	2.70
bruary	27,580	1,300	4,751	3.03	3.16
arch	33,880	3,190	7,844	5.00	5.76
pril	10,480	1,520	3,698	2.36	2.63
ay	3,280	872	1,558	.99	1.14
ne	1,005	605	822	.52	.58
ly	1,640	470	709	.45	.52
ugust	750	360	527	.34	.39
ptember	2,380	275	475	.30	.33
ctober	2,380	410	835	.53	.61
ovember	2,830	470	756	.48	.54
ecember	6,160	1,410	3,140	2.00	2.31
The year	33,880	275	2,899	1.53	20.67

SHENANDOAH RIVER AT MILLVILLE, W. VA.

This river, formed by the junction of the North Fork and the South Fork at Riverton, Va., flows in a northeasterly direction into West Virginia, where it empties into the Potomac at Harpers Ferry.

Observations of the height of Potomac River at the junction of Shenandoah River have been made by the Weather Bureau at Harpers Ferry, W. Va. The gage is on the west face and north end of the second abutment of the old railroad bridge from the West Virginia side of the river. It is of Portland cement, 15 inches wide, plastered on the face of the pier extending to 32 feet, and continued on the iron upright of the bridge to 36 feet. The top surface of the 6-by-6-inch square capstone corresponds to the 32-foot mark on the gage. The elevation is 235.5 feet above mean sea level.

A station was established at Millville, W. Va., April 15, 1895, on Shenandoah River, 4 miles above its mouth. A vertical gage was placed in the river and fastened to a tree, a deep notch being cut in the tree opposite the 8-foot mark. The gage is referred to a bench mark consisting of a copper bolt driven in the foot of a large sycamore tree on the left bank of the river 150 feet below the gage rod, at an elevation of 6.78 feet above the zero mark on the gage. Measurements are made from a cable stretched across the river. The old cable was carried away by the flood of 1896, and a new three-fourths inch galvanized iron-wire cable was put in place on June 23, 1897. The cable, about 500 feet in length, is supported on either bank by a large sycamore tree, and is securely anchored on both sides. The channel is straight, current swift and unobstructed. The banks are low and subject to overflow. The observer is W. R. Nicewarner.

The following discharge measurement was made during 1902 by E. G. Paul.

August 17: Gage height, 0.7 feet; discharge, 811 second-feet.

Daily gage height, in feet, of Shenandoah River at Millville, W. Va.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	7.40	3.10	14.25	3.75	2.20	1.45	1.30	0.90	0.65	0.90	0.80	2.70
	5.30	2.85	9.00	3.40	2.15	1.40	1.20	1.50	.65	.85	.80	2.45
	4.50	3.00	7.20	3.20	2.20	1.35	1.15	1.90	.60	.80	.80	3.10
	4.00	3.00	5.70	3.10	2.25	1.30	1.10	1.70	.60	.70	.80	3.20
	3.50	2.80	5.00	2.90	2.10	1.30	1.05	1.30	.60	.90	.75	4.50
	3.25	2.50	4.50	2.80	2.05	1.30	1.10	1.20	.65	1.00	.75	3.40
	3.00	2.80	4.20	2.60	2.00	1.40	1.10	1.10	.60	.80	.70	3.70
	2.85	2.70	4.20	2.80	4.00	1.25	1.05	1.05	.55	.75	.70	3.20
	2.75	[a]2.20	5.50	6.00	2.70	1.20	1.05	1.00	.60	1.10	.70	2.90
	2.60	[a]2.20	7.80	6.90	2.40	1.20	1.00	.90	.55	.90	.65	2.65
	2.50	[a]2.10	8.00	7.20	2.10	1.15	.95	.80	.55	1.00	.65	2.60
	2.40	[a]2.20	7.40	6.20	2.00	1.10	.90	.80	.55	1.00	.60	2.35
	2.25	[a]2.10	7.20	5.60	2.00	1.10	.90	.80	.50	1.20	.65	2.80
	2.40	[a]2.00	7.00	5.00	1.95	1.00	.90	.80	.50	1.75	.70	3.40
	2.20	[a]2.10	6.00	4.40	1.90	1.10	.80	.80	.55	1.55	.65	3.40
	2.10	1.50	5.00	3.90	1.80	1.20	.80	.75	.55	1.30	.60	3.40
	2.00	1.90	5.20	3.60	1.70	1.20	.80	.70	.50	1.15	.65	4.40
	1.90	2.00	5.90	3.40	1.70	1.10	.80	.70	.50	1.00	.80	4.30
	1.85	2.00	5.00	3.20	1.75	1.00	.75	.85	.50	.95	.80	4.00
	1.80	1.70	4.40	3.00	1.80	1.40	.75	.80	.55	.90	.90	3.50
	1.90	1.00	4.10	2.80	1.75	1.20	.80	.80	.60	.85	.80	3.10
	3.20	2.40	3.80	2.70	1.65	1.20	.80	.80	.60	.80	.90	2.90
	3.40	4.05	3.50	2.60	1.60	1.10	.80	.80	.60	.75	1.00	2.70
	2.90	3.90	3.20	2.50	1.60	1.10	.75	.80	.55	.70	1.00	2.50
	2.50	4.70	3.10	2.40	1.60	1.20	.75	.80	.55	.70	1.00	2.30
	2.30	[b]	2.95	2.30	1.60	1.20	.80	.75	.60	.70	1.20	2.20
	2.50	[b]	2.80	2.25	2.20	1.15	1.00	.70	.60	.65	2.00	2.10
	3.60	11.00	2.75	2.20	1.75	1.10	.90	.70	.60	.90	2.50	2.10
	4.40	.....	3.00	2.20	1.60	1.30	1.30	.70	.65	.85	2.40	2.10
	3.60	.....	3.80	2.20	1.55	1.40	1.30	.65	1.00	.80	2.10	1.90
	3.30	.....	3.90	.....	1.50	.....	1.40	.65	.....	.80	.....	1.80

[a] Backed by ice.

[b] Flood; no measurement.

Rating table for Shenandoah River at Millville, W. Va., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.4	540	2.8	4,160	5.2	10,960	7.6	18,640
.6	740	3.0	4,600	5.4	11,600	7.8	19,280
.8	940	3.2	5,060	5.6	12,240	8.0	19,920
1.0	1,140	3.4	5,540	5.8	12,880	8.5	21,520
1.2	1,370	3.6	6,050	6.0	13,520	9.0	23,120
1.4	1,650	3.8	6,600	6.2	14,160	9.5	24,720
1.6	1,950	4.0	7,190	6.4	14,800	10.0	26,320
1.8	2,260	4.2	7,790	6.6	15,440	10.5	27,920
2.0	2,600	4.4	8,410	6.8	16,080	11.0	29,520
2.2	2,960	4.6	9,040	7.0	16,720		
2.4	3,340	4.8	9,680	7.2	17,360		
2.6	3,740	5.0	10,320	7.4	18,000		

Estimated monthly discharge of Shenandoah River at Millville, W. Va.

[Drainage area, 2,995 square miles.]

Month.	Discharge in second-feet.			Run-off	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	18,000	2,260	4,998	1.67	1.9
February	29,520	1,140	6,503	2.17	2.3
March	39,920	4,055	11,551	3.86	4.4
April	17,360	2,960	6,423	2.14	2.3
May	7,190	1,800	2,613	.87	1.0
June	1,725	1,140	1,425	.48	.5
July	1,650	890	1,122	.37	.4
August	2,430	790	1,089	.36	.4
September	1,140	640	728	.24	.3
October	2,180	790	1,095	.37	.4
November	3,540	740	1,209	.40	.4
December	8,720	2,260	4,653	1.55	1.8
The year	39,920	640	3,618	1.21	16.5

POTOMAC RIVER AT POINT OF ROCKS, MD.

This station was established February 17, 1895, at the toll bridge ver the Potomac River at Point of Rocks. It has been described nd results of measurements have been given in the various annual eports and in the Water-Supply and Irrigation Papers containing eports of the operations at river stations. More or less difficulty as been experienced with the wire gage, due to its stretching, and o record of this lengthening has been noted. A thorough study of ne changes of the gage have been made in this office, based on measrements and on a study of the average depth of soundings, with the esult that it has been found necessary to modify the gage heights in rder to refer them to a common datum. This has also necessitated revision of the rating table. In some cases it has been impossible o reduce the measurements to the known datum, and it has therefore een thought best to discard them and to publish here only such gage eights and discharge measurements as could be reduced to a common latum and on which reliance can be placed as giving a correct estinate of the discharge.

As originally placed the gage was located in the third span of the ridge from the north shore. The next year (1896) the wire became usted and broke frequently, and a new wire gage was placed in the ast side of the first span of the bridge, but it was referred to a diferent datum. During 1897 there was a further change in the length f the gage, which was not recorded, and therefore it has been necesary to discard the records during those two years—that is, 1896 and 1897.

On January 25, 1898, the gage wire was compared with the bench mark, and the observations since that date have been referred to this datum. The bench mark to which the gage has been referred is a copper bolt in a large capstone on the lower wing wall of the north abutment, about 10 feet from the north end of the first iron truss, and 41.30 feet above the datum of the gage. The length of the cable of the wire gage is 44.22 feet. The measurements of 1895 are considered correct within themselves, but there was a difference between the datum of that gage and that of the present standard of 0.4 foot, making it necessary to deduct that amount from the gage readings of 1895 in order to reduce them to the present datum.

On September 2, 1902, a standard chain-and-weight gage was installed at this station to take the place of the wire gage then in use, and is referred to a horizontal scale board graduated to feet and tenths, inclosed in lock box, which is secured by bolts to the end rail of the lower side of the bridge near the left bank. The length of the chain from the zero to the extreme end of the weight is 44.22 feet.

Daily gage height, in feet, of Potomac River at Point of Rocks, Md.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	11.70	3.70	22.50	5.70	2.70	1.80	1.70	1.70	1.00	1.20	1.00	2.7
2	7.20	3.50	29.00	5.00	2.60	1.80	1.80	1.60	.90	1.50	1.00	2.4
3	5.60	3.30	16.10	4.50	2.60	1.70	1.90	1.90	.90	1.10	1.00	2.9
4	4.80	3.20	10.20	4.10	2.60	1.60	1.90	1.90	.90	1.00	1.00	3.4
5	4.20	2.80	8.10	4.00	2.50	1.60	1.80	2.00	.90	1.10	1.00	3.5
6	3.80	2.40	6.70	3.80	2.50	1.50	1.80	1.80	.90	1.30	1.00	3.6
7	3.50	2.50	5.80	4.00	2.50	1.50	1.70	1.70	.80	1.20	.90	4.2
8	3.20	2.60	6.70	6.45	2.40	1.50	1.70	1.70	.80	1.10	.90	4.0
9	3.10	2.50	7.40	16.40	3.10	1.40	1.60	1.60	.80	1.10	.90	3.8
10	3.00	2.50	8.50	14.30	2.70	1.40	1.60	1.50	.80	1.10	.90	3.5
11	2.80	3.50	12.00	12.90	2.50	1.40	1.60	1.40	.80	1.10	.90	3.2
12	2.70	4.00	12.40	12.20	2.30	1.40	1.50	1.30	.80	1.40	.90	3.1
13	2.50	4.20	14.00	11.50	2.20	1.30	1.50	1.30	.70	1.60	1.00	4.1
14	2.30	4.40	13.80	9.30	2.10	1.40	1.50	1.20	.70	1.90	1.00	7.2
15	2.10	5.20	12.00	7.80	2.10	1.40	1.40	1.20	.70	2.00	1.00	7.8
16	2.10	5.40	10.20	6.50	2.00	1.40	1.40	1.20	.70	2.10	1.00	7.5
17	2.10	5.50	8.20	5.90	1.90	1.30	1.30	1.20	.70	2.00	1.00	7.3
18	2.10	5.20	10.60	5.30	1.90	1.30	1.30	1.20	.70	1.80	1.00	6.9
19	2.10	4.80	8.70	4.90	1.90	1.30	1.30	1.20	.70	1.60	1.00	6
20	2.10	4.50	6.60	4.60	2.60	1.30	1.30	1.20	.70	1.40	1.00	5.0
21	2.30	4.50	5.50	4.00	2.00	1.30	1.30	1.10	.70	1.30	.90	4.2
22	3.00	5.60	4.50	3.50	2.00	1.30	1.40	1.10	.70	1.10	.90	3.8
23	6.70	7.00	4.10	3.30	1.90	1.30	1.40	1.10	.70	1.00	.90	3.6
24	5.20	4.10	3.80	3.00	1.90	1.30	1.30	1.10	.70	.90	.90	3.2
25	3.20	4.40	3.60	2.90	1.90	1.20	1.20	1.20	.90	.90	1.10	3.1
26	3.00	17.75	3.50	2.80	2.00	1.40	1.20	1.20	.80	.90	1.50	2.8
27	3.50	26.90	3.50	2.90	2.20	1.50	1.10	1.10	.80	.80	1.90	2.7
28	5.20	19.00	3.60	2.80	2.00	1.40	1.10	1.10	.80	1.00	3.00	2.6
29	5.00	.....	3.70	2.70	1.90	1.40	1.10	1.20	.80	1.00	3.50	2.4
30	4.50	.....	4.30	2.70	1.90	1.40	1.70	1.10	1.00	1.10	2.80	2.3
31	4.20	.....	6.40	.....	1.90	.....	1.80	1.00	.....	1.10	.....	2.2

Rating table for Potomac River at Point of Rocks, Md., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.2	455	2.6	8,835	5.0	22,700	7.4	40,275
.4	570	2.8	9,870	5.2	24,040	7.6	41,935
.6	900	3.0	10,925	5.4	25,380	7.8	43,670
.8	1,356	3.2	11,990	5.6	26,720	8.0	45,390
1.0	1,906	3.4	13,075	5.8	28,080	8.5	49,490
1.2	2,556	3.6	14,180	6.0	29,485	9.0	53,690
1.4	3,286	3.8	15,305	6.2	30,920	9.5	57,990
1.6	4,106	4.0	16,450	6.4	32,410	10.0	62,190
1.8	5,005	4.2	17,620	6.6	33,930	10.5	66,440
2.0	5,925	4.4	18,830	6.8	35,460	11.0	70,690
2.2	6,855	4.6	20,080	7.0	37,000		
2.4	7,825	4.8	21,370	7.2	38,615		

Estimated monthly discharge of Potomac River at Point of Rocks, Md.

[Drainage area, 9,654 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	76,640	6,385	19,079	1.98	2.28
February	205,840	7,825	31,942	3.31	3.44
March	223,690	13,625	54,746	5.67	6.54
April	116,590	9,350	32,232	3.34	3.73
May	11,455	5,465	7,072	.73	.84
June	5,005	2,556	3,413	.35	.39
July	5,465	2,221	3,706	.38	.44
August	5,925	1,906	3,210	.33	.38
September	1,906	1,122	1,351	.14	.16
October	6,385	1,356	2,906	.30	.35
November	13,625	1,616	3,011	.31	.35
December	61,340	8,835	21,382	2.22	2.56
The year	223,690	1,122	15,338	1.59	21.46

MONOCACY RIVER NEAR FREDERICK, MD.

Monocacy River rises in the south-central part of Pennsylvania and flows in a southerly direction through Frederick County, Md., entering Potomac River near the Montgomery County line. A station was established by E. G. Paul, August 4, 1896, at the county iron bridge on the turnpike, 4 miles northeast of Frederick, on the road leading from Frederick to Mount Pleasant, Md., and about 2,000 feet above the mouth of Israel Creek and 3,000 feet below the mouth of Tuscarora Creek, as shown on the Frederick atlas sheet. The drainage area is 665 square miles at this point and 1,000 square miles at the mouth. The gage is attached to the floor timber on the lower side of the bridge. The length of the wire is 35.20 feet. The bench mark is a cross cut in the top face of the capstone on the lower retaining wall of the bridge abutment on the right bank of the stream, and is 29.17 feet above gage datum.

On September 3, 1902, the wire gage in use at this station was replaced by a standard chain and weight gage, referred to a horizontal scale board graduated to feet and tenths, inclosed in a lock box, which is secured to the floor timber on the lower side of the bridge 100 feet from the right bank, by lag bolts. The length of the chain from the zero to the extreme end of the weight is 35.20 feet.

The stream at this station has two channels, being divided by a small, low island, which serves as a foundation for the middle pier of the bridge. The right channel is measured from the lower side of the bridge, and the left channel from the upper side, as these sections are freer from rocks than a continuous section on either side of the bridge. The stream is subject to high water and sudden floods, owing to the character of its upper watershed. The observer is E. L. Derr, a farmer near Frederick, Md.

The following discharge measurement was made during 1902 by E. G. Paul:

September 4; Gage height, 3.74 feet; discharge, 100 second-feet.

Daily gage height, in feet, of Monocacy River near Frederick, Md.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	8.50	5.90	25.20	7.00	5.20	4.30	6.90	5.20	3.70	4.60	5.10	4.8
2	8.20	5.90	14.50	6.90	5.10	4.30	6.40	4.50	3.70	6.00	5.00	7.0
3	7.10	5.90	10.90	10.50	5.10	4.30	4.90	4.20	3.70	5.10	4.90	11.0
4	6.00	8.50	10.20	8.50	5.00	4.20	4.80	4.10	3.70	4.90	4.70	8.0
5	7.90	8.50	9.60	8.30	4.90	4.20	4.80	4.10	3.90	4.50	4.60	6.9
6	8.20	8.10	9.20	8.00	4.90	4.10	4.80	4.20	3.70	7.10	4.50	7.0
7	8.10	7.90	9.10	7.90	4.80	4.10	4.80	4.20	3.60	5.20	4.40	7.0
8	7.50	7.80	8.90	7.50	4.80	4.10	4.60	4.10	3.60	5.10	4.60	7.0
9	5.90	7.40	9.90	17.90	4.70	4.10	4.50	4.00	3.60	5.00	4.30	7.0
10	5.50	6.90	15.20	16.90	4.70	4.10	4.40	4.00	3.60	4.90	4.50	7.0
11	5.40	6.50	15.50	8.20	4.70	4.10	4.30	4.00	3.60	5.50	4.50	7.0
12	5.40	6.50	12.20	7.50	4.60	4.00	4.20	4.00	3.52	12.80	4.40	6.9
13	5.30	6.50	14.50	7.30	4.60	7.10	4.10	3.90	3.50	8.10	4.40	11.5
14	5.30	6.30	10.10	6.90	4.60	5.50	4.00	3.90	3.50	6.50	4.40	9.5
15	5.20	6.10	10.00	6.50	4.60	4.20	4.00	3.80	3.50	5.10	4.30	8.0
16	5.10	5.90	9.50	6.30	4.60	4.20	3.90	3.80	3.50	4.90	4.20	8.0
17	4.90	5.90	14.60	6.10	4.50	4.20	3.90	3.80	3.50	4.70	4.20	10.0
18	4.90	5.90	10.20	5.90	4.50	4.10	3.90	3.80	3.50	4.60	4.20	9.0
19	4.90	5.90	8.40	5.80	4.50	4.10	4.10	3.80	3.50	4.50	4.40	8.0
20	4.90	6.10	8.10	5.70	4.50	4.10	4.10	3.80	3.60	4.40	4.50	9.0
21	7.20	10.20	7.90	5.60	4.50	4.20	5.20	3.70	3.60	4.30	4.40	10.5
22	18.05	14.40	7.40	5.50	4.50	4.20	4.30	3.70	3.60	4.20	4.30	11.0
23	7.10	9.60	7.10	5.40	4.50	4.10	4.20	3.70	3.50	4.20	4.20	10.0
24	6.90	9.40	6.90	5.30	4.40	4.10	4.10	3.60	3.50	4.20	4.20	9.0
25	6.10	10.50	6.50	5.30	4.40	4.10	4.10	3.60	3.80	4.10	4.20	9.0
26	6.90	24.06	6.30	5.20	4.40	5.90	4.00	3.60	4.00	4.10	5.00	9.0
27	11.15	21.40	6.00	5.10	4.50	5.60	4.00	3.60	9.10	4.10	9.40	8.0
28	7.50	19.35	6.00	5.00	4.50	5.10	3.90	4.10	5.10	13.70	7.00	8.0
29	6.90	.....	5.90	5.20	4.40	4.50	3.90	3.90	4.90	9.50	5.90	8.0
30	6.50	.....	5.60	5.20	4.30	4.50	4.50	3.70	4.80	5.50	5.90	8.0
31	6.20	.....	6.20	.....	4.30	.....	5.50	3.70	.....	5.30	.....	8.0

Rating table for Monocacy River near Frederick, Md., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.6	45	6.2	1,192	10.0	4,460	16.5	10,050
3.8	90	6.4	1,364	10.5	4,890	17.0	10,480
4.0	150	6.6	1,536	11.0	5,320	17.5	10,910
4.2	210	6.8	1,708	11.5	5,750	18.0	11,340
4.4	270	7.0	1,880	12.0	6,180	18.5	11,770
4.6	340	7.2	2,052	12.5	6,610	19.0	12,200
4.8	420	7.4	2,224	13.0	7,040	19.5	13,060
5.0	500	7.6	2,396	13.5	7,470	.....	.....
5.2	600	7.8	2,568	14.0	7,900	.....	.....
5.4	700	8.0	2,740	14.5	8,330	.....	.....
5.6	800	8.5	3,170	15.0	8,760	.....	.....
5.8	900	9.0	3,600	15.5	9,190	.....	.....
6.0	1,020	9.5	4,030	16.0	9,620	.....	.....

Estimated monthly discharge of Monocacy River near Frederick, Md.

[Drainage area, 665 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	11,283	460	1,918	2.88	3.32
February	16,500	960	3,645	5.48	5.71
March	17,532	800	4,398	6.61	7.62
April	11,254	500	2,206	3.32	3.70
May	600	240	358	.54	.62
June	1,966	180	338	.51	.57
July	1,794	120	351	.53	.61
August	600	45	137	.21	.24
September	3,686	27	215	.32	.36
October	7,642	180	1,135	1.71	1.97
November	3,944	210	567	.85	.95
December	10,566	750	3,835	5.77	6.65
The year	17,532	27	1,592	2.39	32.32

JAMES RIVER BASIN.

James River, like the Potomac, rises among mountain ridges, having a general northeasterly and southwesterly trend, the tributaries flowing along narrow valleys and finally uniting to cut the mountains transversely, the waters escaping in a southeasterly direction toward the sea. The main stream is formed by the junction of Jackson and Cowpasture rivers, both of these rising in the central part of the western border of Virginia. The river and the water powers along it are fully described by Prof. George F. Swain in his report of the Water Powers of the Middle Atlantic Watershed, pages 13–33, contained in Vol. XVI of the Tenth Census.

Records of measurements have been kept as in previous years on North (of James) River at Glasgow, Va.; on James River at Buchanan, Va., Holcomb Rock, Va., and at Cartersville, Va., and on the Appomattox River at Mattoax, Va.

The description of the stations, together with the records for 1902, are given in the following pages.

NORTH (OF JAMES) RIVER AT GLASGOW, VA.

This river rises on the western slope of the Shenandoah Mountains and flows in a southeasterly direction across the valley between the Shenandoah and Blue Ridge ranges, emptying into James River about 17 miles south of Lexington, Va. Its drainage basin is largely under cultivation, except in the upper part, where it is mountainous and covered with forest growth. This station was established at the East Glasgow County bridge, about 1 mile above the mouth of North River, by C. C. Babb and D. C. Humphreys, on August 21, 1895. The height of water is observed by means of a wire gage, the board being placed on the guard rail on the lower side of the bridge, and graduated in feet and tenths. This gage is referred to a bench mark at the top of the top chord of the bridge over the gage pulley at an elevation of 32.2 feet. The distance from the end of the weight to the marker of the gage is 27.86 feet. The measurements of discharge are made from the bridge, the initial point for soundings being on the left bank. The channel is straight for about 600 feet above and below the station; the current rather sluggish, but with sufficient velocity for measurements. There is a dam on the North River 10 miles above the station, but its influence on the flow is scarcely noticeable. The right bank is high, but the left bank is subject to overflow in very high water. The bed is of rock and gravel and fairly permanent. The observer is B. G. Baldwin, a merchant of Glasgow, Va.

The following discharge measurements were made during 1902 by D. C. Humphreys:

June 25: Gage height, 1.90 feet; discharge, 907 second-feet.
July 10: Gage height, 0.83 feet; discharge, 201 second-feet.
August 20: Gage height, 0.61 feet; discharge, 132 second-feet.

Daily gage height, in feet, of North (of James) River at Glasgow, Va.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	5.20	3.00	9.00	2.85	1.40	1.00	1.80	1.05	0.50	0.65	0.60	1.90
2	4.60	2.70	4.85	2.55	1.35	1.00	1.15	[a]1.00	.51	.60	.55	2.20
3	3.30	2.70	4.15	2.20	1.50	.98	.95	1.00	.50	[b].60	.70	2.40
4	2.65	2.60	3.60	2.10	1.50	.98	.85	.95	.51	[b].65	.70	2.80
5	2.55	2.45	3.45	2.00	1.48	.95	.82	.95	.51	1.12	.65	2.75
6	2.45	2.25	3.00	2.00	1.48	.95	.80	.90	.50	1.35	.55	2.15
7	2.20	2.15	2.80	2.50	1.45	.90	.80	.90	.50	.95	.60	1.90
8	2.10	2.00	2.80	2.85	1.45	.90	.80	.85	.50	.75	.70	1.85
9	2.00	1.85	3.85	3.75	1.50	.90	.80	.85	.52	.70	.72	1.80
10	1.90	1.65	4.90	3.85	1.40	.90	.78	.80	.50	.70	.72	1.60
11	1.82	1.60	4.00	3.50	1.35	.90	.75	.80	.50	.70	.70	1.50
12	1.70	1.58	3.60	3.30	1.30	1.00	.75	.75	.50	1.40	.70	1.50
13	1.65	1.52	4.00	3.80	1.28	2.25	.72	.75	.50	1.20	.65	1.60
14	1.60	1.50	3.50	3.00	1.25	1.30	.70	.70	.50	1.00	.65	1.60
15	1.55	1.50	3.15	2.35	1.25	1.15	.68	.70	.51	.90	.65	2.00
16	1.52	1.45	3.00	2.25	1.20	1.12	.65	.70	.50	.85	.70	2.60
17	1.50	1.42	3.50	2.20	1.15	1.10	.65	.70	.50	.80	1.10	4.30
18	1.45	1.50	3.00	2.10	1.12	1.05	.62	.70	.50	.75	1.00	3.10
19	1.42	1.45	2.65	2.00	1.10	1.00	.62	.70	.50	.72	.95	2.60
20	1.40	1.40	2.45	1.90	1.25	1.00	.60	.61	.50	.70	.90	2.20
21	1.45	2.30	2.40	1.80	1.15	.95	.60	.55	.50	.62	.85	2.00
22	1.50	2.10	2.35	1.75	1.10	.95	.58	.50	.52	.58	.80	2.00
23	1.45	1.49	2.30	1.70	1.10	.92	.58	.50	.55	.65	.80	1.85
24	1.48	2.50	2.25	1.65	1.10	.92	.55	.51	.50	.58	.80	1.75
25	1.42	10.20	2.20	1.60	1.10	1.90	.58	.50	.56	.55	.80	1.60
26	2.60	7.50	2.10	1.55	1.15	1.15	.60	.52	.60	.52	1.80	1.60
27	3.90	5.60	2.00	1.50	1.10	1.15	.60	.52	.60	.62	2.20	1.50
28	4.10	12.58	1.90	1.48	1.08	1.10	.60	.51	.60	.72	1.80	1.45
29	3.50	.....	1.85	1.45	1.08	1.10	.62	.50	.57	.75	1.90	1.40
30	3.25	.....	2.15	1.40	1.05	1.10	.70	.50	.56	.80	2.10	1.40
31	3.00	.....	3.30	.....	1.05	.....	1.18	.51	.....	.79	.....	1.30

[a] Interpolated August 2 to 19, inclusive. [b] Interpolated.

Rating table for North (of James) River at Glasgow, Va., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.0	25	2.2	1,260	4.4	4,860	7.5	11,145
.2	50	2.4	1,500	4.6	5,239	8.0	12,170
.4	100	2.6	1,770	4.8	5,628	8.5	13,195
.6	150	2.8	2,050	5.0	6,030	9.0	14,220
.8	200	3.0	2,350	5.2	6,438	10.0	16,270
1.0	270	3.2	2,760	5.4	6,846	11.0	18,320
1.2	380	3.4	3,090	5.6	7,254	12.0	20,370
1.4	500	3.6	3,430	5.8	7,662	13.0	22,420
1.6	660	3.8	3,770	6.0	8,070	14.0	24,470
1.8	840	4.0	4,130	6.5	9,095	.....	.....
2.0	1,020	4.2	4,490	7.0	10,120	.....	.....

Estimated monthly discharge of North (of James) River at Glasgow, Va.

[Drainage area, 831 square miles.]

Month	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches
1902.					
January	6,438	500	1,666	2.00	2.31
February	13,400	500	2,628	3.16	3.29
March	14,220	885	2,881	3.47	4.00
April	3,860	500	1,519	1.83	2.04
May	580	297	419	.50	.58
June	1,320	235	340	.41	.46
July	440	137	194	.23	.27
August	297	125	181	.22	.25
September	150	125	129	.15	.17
October	500	125	210	.25	.29
November	1,260	137	324	.39	.44
December	4,680	440	1,140	1.37	1.58
The year	14,220	125	969	1.16	15.66

JAMES RIVER AT BUCHANAN, VA.

This river rises in the Allegheny Mountains, on the western border of Virginia, and flows in an easterly direction across the State into Chesapeake Bay. The upper part of its drainage area is mountainous and largely covered with forests, while in the eastern part of the State the river flows through a flat and cultivated area. Measurements of flow are made at Buchanan, in Botetourt County, and at Cartersville, 50 miles above Richmond. The station at Buchanan was established by C. C. Babb and D. C. Humphreys, August 18, 1895. It is about 20 miles above the mouth of North River and one-half mile above the mouth of Purgatory Creek, as shown on the Natural Bridge topographic atlas sheet. The area as far as this point is mapped on the Natural Bridge, Staunton, Monterey, Lewisburg, Dublin, Christiansburg, and Roanoke sheets. The United States Weather Bureau had maintained a gage here for about two years before measurements were made by the Geological Survey. The wire gage is suspended from the steel highway bridge, which crosses the river on two spans. On April 3, 1897, the zero of this gage was lowered 2 feet to avoid negative readings. The gage is referred to a scale divided into feet and tenths, and to two bench marks. First, the top of the upper end of the third floor beam from left bank is 30 feet above the zero of the

ge. Second, the top of a stone post under the southwest corner of porch of the Chesapeake and Ohio Railroad passenger station is 68 feet above zero of gage. A third bench mark is on a permanent ledge of rock on the left bank about 500 feet above the bridge, at an elevation of 17.48 feet above the zero of the gage. The tial point of soundings is on the left bank, upper side of the bridge, rked with the end pin of the truss. The channel is straight, the w fairly swift, and without obstructions. The bed is rocky; banks gh and not subject to overflow. The observer is U. H. Hyde, a egraph operator for the Chesapeake and Ohio Railroad, at Buchanan, Va.

The following discharge measurements were made during 1902 by C. Humphreys:

July 19: Gage height, 2.12 feet; discharge, 519 second-feet.
August 25: Gage height, 1.90 feet; discharge, 365 second-feet.

Daily gage height, in feet, of James River at Buchanan, Va.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
	7.35	6.15	19.05	5.40	3.00	2.60	3.15	2.20	2.00	2.20	2.10	3.80
	6.20	5.80	9.05	4.95	3.00	2.60	2.85	2.45	2.00	2.20	2.10	4.55
	5.40	5.70	7.50	4.65	3.00	2.60	2.65	2.40	2.00	2.20	2.10	5.25
	4.95	5.45	6.25	4.50	3.00	2.60	2.50	2.40	2.00	2.20	2.10	5.35
	4.55	5.00	5.60	4.60	3.00	2.50	2.50	2.30	2.00	2.65	2.10	5.00
	4.25	4.50	5.25	4.50	2.90	2.50	2.40	2.30	2.00	2.55	2.10	5.10
	4.05	4.20	5.00	4.50	2.90	2.50	2.40	2.30	2.00	2.35	2.00	4.40
	3.90	3.95	5.20	5.00	2.90	2.50	2.30	2.30	1.90	2.20	2.00	3.95
	3.80	3.85	6.30	5.90	2.90	2.40	2.40	2.20	1.90	2.10	2.00	3.65
	3.65	3.70	7.10	5.80	2.90	2.40	2.50	2.20	1.90	2.10	2.00	3.45
	3.50	3.60	6.60	5.75	2.90	2.40	2.50	2.20	1.90	2.25	2.00	3.30
	3.40	3.50	6.55	5.55	2.80	2.50	2.40	2.10	1.90	2.45	2.00	3.20
	3.30	3.40	6.70	5.25	2.80	2.80	2.40	2.10	1.90	2.50	2.00	3.20
	3.15	3.30	8.00	4.90	2.80	3.10	2.30	2.10	1.90	2.50	2.00	4.25
	3.00	3.20	7.50	4.45	2.80	2.95	2.30	2.20	1.90	2.40	2.00	4.45
	3.00	3.20	7.05	4.25	2.70	2.80	2.30	2.30	1.90	2.40	2.00	4.45
	3.00	3.20	8.65	4.05	2.70	2.70	2.20	2.20	1.90	2.30	2.00	6.35
	3.00	3.10	7.40	3.90	2.70	2.60	2.10	2.20	1.90	2.30	2.65	6.10
	3.00	3.10	5.95	3.80	2.70	2.50	2.10	2.10	1.90	2.20	3.30	4.95
	2.90	3.20	5.35	3.70	2.70	2.40	2.10	2.10	1.90	2.10	2.85	4.30
	2.90	3.30	4.90	3.60	2.70	2.40	2.10	2.10	1.90	2.10	2.55	3.95
	2.90	3.50	4.55	3.50	2.60	2.40	2.10	2.00	1.90	2.10	2.40	4.15
	2.90	3.75	4.25	3.40	2.60	2.40	2.10	2.00	1.90	2.10	2.30	4.25
	2.90	4.20	4.10	3.40	2.70	2.40	2.10	2.00	1.90	2.10	2.20	3.95
	2.90	10.10	4.00	3.30	2.70	2.40	2.10	2.00	1.90	2.00	2.45	3.75
	3.30	14.40	3.85	3.30	2.80	3.00	2.10	2.00	2.05	2.00	3.80	3.65
	5.05	9.55	3.70	3.20	2.90	2.90	2.10	2.00	2.10	2.00	4.55	3.25
	8.40	15.35	3.70	3.10	2.90	2.80	2.10	2.00	2.15	2.30	4.10	3.00
	6.15	.....	5.60	3.10	2.80	2.80	2.10	2.00	2.30	2.30	3.50	3.25
	5.70	.....	8.05	3.10	2.80	2.90	2.10	2.00	2.30	2.20	3.15	3.15
	6.55	.....	6.20	.....	2.70	.....	2.20	2.00	.....	2.20	.....	3.00

Rating table for James River at Buchanan, Va., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
1.6	310	4.8	4,640	8.0	12,620	16.0	33,7[illegible]
1.8	360	5.0	5,060	8.5	13,940	16.5	35,0[illegible]
2.0	430	5.2	5,495	9.0	15,260	17.0	36,2[illegible]
2.2	540	5.4	5,950	9.5	16,580	17.5	37,5[illegible]
2.4	670	5.6	6,425	10.0	17,900	18.0	39,0[illegible]
2.6	840	5.8	6,911	10.5	19,220	18.5	40,3[illegible]
2.8	1,050	6.0	7,403	11.0	20,540	19.0	41,6[illegible]
3.0	1,330	6.2	7,903	11.5	21,860	19.5	42,9[illegible]
3.2	1,650	6.4	8,411	12.0	23,180	20.0	44,3[illegible]
3.4	1,980	6.6	8,927	12.5	24,500	20.5	45,6[illegible]
3.6	2,330	6.8	9,452	13.0	25,820	21.0	46,9[illegible]
3.8	2,690	7.0	9,980	13.5	27,140	21.5	48,2[illegible]
4.0	3,050	7.2	10,508	14.0	28,460	22.0	49,5[illegible]
4.2	3,440	7.4	11,036	14.5	29,780	22.5	50,9[illegible]
4.4	3,840	7.6	11,564	15.0	31,100		
4.6	4,240	7.8	12,092	15.5	32,420		

Estimated monthly discharge of James River at Buchanan, Va.

[Drainage area, 2,058 square miles.]

Month.	Discharge in second-feet.			Run-off	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	13,676	1,180	3,666	1.78	[illegible]
February	31,954	1,490	6,157	2.99	[illegible]
March	41,794	2,510	8,730	4.24	[illegible]
April	7,156	1,490	3,335	1.62	[illegible]
May	1,330	840	1,083	.53	[illegible]
June	1,490	670	877	.43	[illegible]
July	1,570	480	634	.31	[illegible]
August	710	430	516	.25	[illegible]
September	600	390	422	.21	[illegible]
October	890	430	573	.28	[illegible]
November	4,140	430	951	.46	[illegible]
December	8,283	1,330	3,434	1.67	[illegible]
The year	41,794	390	2,532	1.23	[illegible]

JAMES RIVER AT CARTERSVILLE, VA.

bservations of the height of James River are made by the Weather eau at Lynchburg, Va., 48 miles below Buchanan and about 100 s above Cartersville. The drainage area is given as 3,700 square s. The gage is on the first pier of the Amherst bridge, at the of Ninth street, on the side facing Lynchburg, about 100 feet n the shore. The elevation is 494.7 feet above mean sea level. highest water was about 27 feet on September 30, 1870, and the est —0.3 feet on September 12–15, 1895.

Gages were established on James River in 1893 by F. B. Isaacs, gineer for water power of the Chesapeake and Ohio Railway Comy, at Ninemile Locks, Columbia, Scottsville, Lynchburg, Balcony lls, Buchanan, Eagle Mountain, and Clifton Forge. Records of ghts of water at these points were made twice daily from 1893 to 97, and freshet reports were obtained for these years. The gages re not referred to any fixed datum, but the zero of each gage was at what was considered ordinary low water in the river. During e latter part of 1899 records have been resumed, excepting at ottsville, Balcony Falls, and Eagle Mountain, where the gages have en abandoned.

At Boshers dam, 9 miles above Richmond, is a gage where the height water is recorded twice daily, showing the supposed head on the est of dam. This crest, however, is so irregular that the coefficient discharge has not been ascertained. Another complication exists the fact that water is deflected into a canal, the quantity not being nown.

Observations are maintained by the Weather Bureau at Richmond, a., the gage being at the foot of Virginia street, near Fourteenth, mmediately east of the Richmond and Danville Railroad bridge. It s a standard brass Weather Bureau gage embedded in the cement buttress. The elevation of the zero is 2.8 feet.

A gaging station was established January 1, 1899, by D. C. Humphreys, and is located at the highway bridge crossing the James at Cartersville, one-half mile from railroad station and 50 miles above Richmond, Va. The wire gage is attached to a horizontal gage rod fastened to the bridge and is referred to a bench mark, the top of the lower end of the fourth-floor beam from the right bank, which is 32.04 feet above the zero of the gage. The gage was verified June 23, 1899. The channel is straight for one-third of a mile above and 1 mile below the station, the current fairly swift, and the bottom somewhat sandy and shifting. The banks are high and not subject to overflow except in extreme high water. The observer is Julien I. Palmore, clerk in a store at Cartersville, Va.

The following discharge measurements were made during 1902 by D. C. Humphreys:

July 15: Gage height, 1.10 feet; discharge, 2,008 second-feet.
August 25: Gage height, 0.80 feet; discharge, 1,482 second-feet.

Daily gage height, in feet, of James River, at Cartersville, Va.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	Dec.
1902.												
1	16.50	7.50	22.90	8.00	3.45	1.98	1.70	1.48	0.60	1.40	1.80	
2	11.20	8.00	22.05	6.40	3.10	1.70	1.55	1.30	.55	1.40	1.62	
3	8.80	9.60	14.00	5.40	3.40	1.68	2.00	1.80	.52	1.40	1.52	
4	7.20	8.00	10.50	5.20	3.30	1.30	1.70	2.10	.50	1.00	1.42	
5	6.15	7.05	9.50	5.10	2.80	1.40	1.70	1.70	.52	7.95	1.40	
6	5.55	5.50	9.20	4.70	3.40	1.30	1.40	2.15	.80	16.85	1.30	
7	5.25	5.05	7.75	4.80	3.30	1.20	1.40	2.00	.75	5.60	1.70	
8	5.00	4.92	7.00	7.20	3.00	1.40	1.60	1.90	.60	4.05	1.30	
9	4.88	4.22	8.70	10.80	2.90	1.30	1.90	1.30	1.00	3.25	1.30	
10	4.38	3.88	8.60	8.30	2.80	1.20	1.50	1.60	1.00	2.40	1.30	
11	4.00	3.62	9.20	7.60	2.55	1.20	1.80	1.70	.90	1.60	1.25	
12	3.68	3.50	8.80	7.10	2.40	1.35	1.42	1.00	.90	10.02	1.30	
13	3.40	3.60	8.20	6.52	2.10	1.20	1.38	1.05	.88	5.72	1.32	
14	3.30	3.30	8.00	5.54	2.80	1.35	1.20	1.10	.75	3.80	1.22	
15	3.25	3.12	8.72	5.31	2.00	1.30	1.00	1.30	.70	2.80	1.20	
16	3.00	3.10	7.90	5.10	2.00	2.50	1.00	4.25	.60	2.20	1.25	
17	2.95	3.10	10.70	4.50	2.20	14.35	1.00	3.15	.55	2.05	1.20	
18	2.90	2.82	10.05	4.40	2.15	4.70	1.00	1.45	.53	1.87	2.50	
19	2.88	2.60	9.80	4.35	2.10	3.10	1.00	1.25	.50	1.72	4.22	
20	2.72	2.70	7.72	4.05	1.90	2.13	1.22	1.20	.50	1.65	3.30	
21	2.72	3.10	6.70	3.20	2.38	1.88	1.32	1.00	.60	1.60	2.52	
22	7.15	7.70	6.20	3.60	2.40	1.72	1.30	1.15	1.00	1.52	2.40	
23	6.12	7.70	5.50	3.50	2.00	1.60	1.20	1.10	.70	1.42	2.20	
24	4.80	7.00	5.20	3.40	3.00	1.60	1.10	.90	.60	1.35	1.90	
25	3.60	10.20	4.70	3.30	3.40	1.58	1.00	.90	.70	1.80	2.30	
26	3.30	21.90	4.30	3.20	3.50	2.00	.92	.80	2.00	1.28	2.35	
27	5.72	19.20	4.20	3.10	2.40	2.30	.88	.82	4.35	1.20	6.20	
28	9.44	17.28	3.90	2.90	2.20	2.00	.80	.70	1.75	6.11	5.30	
29	10.10	.....	5.20	3.00	2.20	1.78	.78	.80	1.35	4.00	5.00	
30	8.00	.....	7.20	3.80	2.10	1.80	.65	.70	1.40	2.30	5.15	
31	7.80	.....	9.40	.....	2.00	.....	1.62	.65	.....	2.00	.....	

Rating table for James River at Cartersville, Va., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.4	702	4.0	7,600	7.6	18,380	16.0	46,100
.6	1,000	4.2	8,100	7.8	19,040	16.5	47,750
.8	1,296	4.4	8,610	8.0	19,700	17.0	49,400
1.0	1,600	4.6	9,130	8.5	21,350	17.5	51,050
1.2	1,916	4.8	9,660	9.0	23,000	18.0	52,700
1.4	2,243	5.0	10,200	9.5	24,650	18.5	54,350
1.6	2,582	5.2	10,760	10.0	26,300	19.0	56,000
1.8	2,932	5.4	11,330	10.5	27,950	19.5	57,650
2.0	3,294	5.6	11,910	11.0	29,600	20.0	59,300
2.2	3,672	5.8	12,500	11.5	31,250	20.5	60,950
2.4	4,063	6.0	13,100	12.0	32,900	21.0	62,600
2.6	4,463	6.2	13,760	12.5	34,550	21.5	64,250
2.8	4,871	6.4	14,420	13.0	36,200	22.0	65,900
3.0	5,300	6.6	15,080	13.5	37,850	22.5	67,550
3.2	5,740	6.8	15,740	14.0	39,500	23.0	69,200
3.4	6,190	7.0	16,400	14.5	41,150	24.0	72,500
3.6	6,650	7.2	17,060	15.0	42,800	25.0	75,800
3.8	7,120	7.4	17,720	15.5	44,450	.....	.....

Estimated monthly discharge of James River at Cartersville, Va.

[Drainage area, 6,232 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	47,750	4,666	12,814	2.06	2.38
February	65,570	4,463	16,494	2.65	2.76
March	68,870	7,360	22,368	3.59	4.14
April	28,940	5,083	10,966	1.76	1.96
May	6,420	3,111	4,516	.72	.83
June	40,655	1,916	4,231	.68	.76
July	3,294	1,074	2,077	.33	.38
August	8,225	1,074	2,374	.38	.44
September	8,480	850	1,579	.25	.28
October	48,905	1,916	7,078	1.14	1.31
November	24,155	1,916	4,918	.79	.88
December	30,920	5,410	13,048	2.09	2.41
The year	68,870	850	8,539	1.37	18.53

JAMES RIVER AT HOLCOMBS ROCK, VA.

This station was established by the Willson Aluminum Company of Holcombs Rock, Va., in 1899, in connection with measurements to determine the horsepower available at that point. During 1900 the records were fragmentary, but at the commencement of 1901 daily records were taken, which have been furnished to the Geological Survey through the courtesy of George O. Seward, general manager of the company. The gage consists of a copper float 8 by 8 by 8 inches with a vertical rod 1½ inches square attached to it, the rod, which extends up through the powerhouse floor, being graduated to tenths of a foot. The copper float is inclosed in a 12-inch by 12-inch by 12-foot box, which rests solidly on the bottom of the river. The box is perforated, so that the water in it will always stand at the same level as the water in the river, while the float, being inclosed, is not in danger of being broken by floating timber. The fluctuations of the river are read directly from the rod, which moves up or down with the float as it responds to the variations in the height of the river. Measurements of discharge are not made at this point.

Daily gage height, in feet, of James River at Holcombs Rock, Va.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1902.												
1	9.50	5.80	19.00	.....	1.90	1.60	1.80	1.15	0.90	1.35	0.80	2.0
2	7.50	5.25	16.40	.....	1.80	1.50	1.45	1.20	.90	1.55	.90	6
3	5.50	5.80	8.10	.....	1.95	1.50	1.30	1.00	.90	2.05	.85	4.2
4	4.75	5.15	6.05	.....	1.90	1.40	1.20	1.15	.90	2.25	.80	3.4
5	4.00	4.10	5.10	.....	2.00	1.40	1.20	1.10	.90	2.25	.85	4.7
6	3.55	3.70	4.50	.....	1.80	1.40	1.20	1.20	.90	2.10	1.15	4.8
7	3.28	3.35	4.35	.....	1.80	1.30	1.25	1.20	.90	1.55	1.05	3.8
8	3.10	3.20	4.80	.....	2.00	1.30	1.00	1.10	.90	1.10	1.00	3.0
9	2.85	3.05	5.85	.....	2.00	1.30	1.20	.95	.90	1.15	1.15	2.8
10	2.75	2.55	7.20	.....	1.80	1.20	1.15	.45	.90	1.10	1.35	2.4
11	2.60	2.35	6.80	.....	1.80	1.20	1.25	.95	.85	1.05	1.05	2.0
12	2.45	2.30	6.40	.....	1.70	1.20	1.10	.80	.85	1.65	.80	1.8
13	2.30	2.20	6.20	.....	1.70	1.65	1.05	.85	.85	1.90	1.00	2.6
14	2.10	2.10	6.60	.....	1.70	1.60	1.00	.95	.00	1.20	1.00	2.5
15	2.00	2.00	6.20	.....	1.60	1.50	1.10	.95	.60	1.10	.90	2.5
16	2.00	1.90	4.95	.....	1.50	1.80	1.10	1.10	.80	1.20	1.00	3.0
17	2.00	1.90	4.55	.....	1.50	1.65	.90	.55	.75	1.10	1.05	3.3
18	2.00	1.90	3.90	.....	1.50	1.35	.85	.60	.75	1.00	1.00	4.2
19	1.90	1.80	3.55	.....	1.30	1.40	.95	.95	.80	1.10	1.00	4.5
20	1.90	1.70	3.40	.....	1.30	1.35	.00	.85	.85	1.20	1.40	3.9
21	1.95	2.15	3.00	.....	1.55	1.20	1.20	.75	.00	1.15	1.55	2.9
22	2.00	2.60	3.10	.....	1.55	1.20	1.10	.75	.95	.90	1.25	2.4
23	1.95	2.70	.....	.....	1.55	1.35	1.00	.70	.80	.90	1.30	3.0
24	1.85	3.35	.....	.....	1.55	1.15	.90	.60	.85	.80	1.15	3.0
25	1.80	10.50	.....	.....	1.60	1.15	.80	.90	.85	.85	1.50	2.6
26	1.95	13.00	.....	.....	1.70	1.55	.80	.75	.85	.75	2.05	2.2
27	6.85	10.30	.....	1.90	1.70	1.60	.00	.80	.95	1.05	3.65	2.1
28	8.20	11.90	.....	1.90	1.80	1.40	1.00	.80	.55	1.10	3.05	1.7
29	6.40	.....	.....	1.90	1.65	1.50	.80	.80	1.05	1.20	2.40	1.5
30	5.10	.....	.....	1.90	1.60	1.60	.95	.90	1.10	.90	2.05	1.4
31	5.75	.....	.....	.....	1.60	.....	1.15	.65	.....	.80	.....	1.5

APPOMATTOX RIVER AT MATTOAX, VA.

is station was established in August, 1900, at the crossing of the hern Railway, 27 miles southwest of Richmond. The gage rod, h is on the guard rail of the bridge, is laid off to feet and tenths, uations being indicated by brass nails. The zero of the rod is feet from the west end of the bridge, on the upstream side. The r rim of the pulley is 0.9 foot from the zero of the rod; the dis- e from the end of the weight to the pointer on the wire rope is 5 feet. When the gage reading is 1 foot the water level is 45.6 below the top surface of the upper chord of the bridge, upstream , and at the zero of the gage.

he river here is straight for a considerable distance above the ion, but there is an abrupt bend about 100 feet below the bridge. river is very narrow, and at the low stage at which the gage was ed the current velocity is not very well distributed, there being ctically no current for several feet next to the west bank. It was sible, however, to secure a good gaging, and old residents stated t the river was at the lowest stage it had reached in fourteen years. e Mattoax railroad station is located on the west bank of the river. l J. C. Carter, the station agent, is the observer.

The following measurements have been made during 1902 by B. S. ane:

July 10: Gage height, 1.80 feet; discharge, 391 second-feet.
August 16: Gage height, 7.68 feet; discharge, 2,266 second-feet.
October 14: Gage height, 5.75 feet; discharge, 1,410 second-feet.
October 14: Gage height, 4.88 feet; discharge, 1,144 second-feet.
December 6: Gage height 13.10 feet; discharge, 4,857 second-feet.

Daily gage height, in feet, of Appomattox River at Mattoax, Va.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	De
1902.												
1	15.50	5.90	21.00	4.00	7.00	1.60	3.10	2.00	0.60	1.60	2.50	
2	22.00	5.90	16.00	3.50	4.70	1.60	3.30	4.50	.50	1.90	2.5	
3	15.00	11.00	15.00	3.25	4.00	1.50	2.75	2.90	.50	2.10	2.5	
4	4.75	11.50	12.00	3.10	4.00	1.50	1.80	2.00	.80	1.10	1.8	
5	3.80	12.00	10.00	3.10	4.50	1.40	1.80	3.60	1.30	2.00	1.7	
6	3.80	8.00	9.70	3.60	3.30	1.35	1.60	3.30	1.20	10.00	1.7	
7	3.15	4.90	10.50	3.65	3.60	1.25	1.65	2.00	1.00	11.00	1.7	
8	3.80	4.70	7.00	8.00	3.80	1.20	1.65	4.20	.80	11.50	1.7	
9	3.20	4.30	6.00	10.50	4.20	1.30	2.00	2.70	.75	3.80	1.7	
10	3.15	3.50	6.50	11.00	3.50	1.30	1.70	1.65	3.00	2.30	1.6	
11	3.20	3.15	5.00	10.90	3.80	1.25	2.00	1.60	3.50	2.25	1.5	
12	3.10	3.30	4.80	5.00	2.50	1.25	1.30	3.60	2.30	4.70	1.45	
13	2.75	3.20	4.50	4.15	2.45	1.20	1.30	1.70	1.30	7.80	1.4	
14	2.10	3.25	4.20	3.15	2.45	1.20	1.25	1.30	1.00	6.50	1.45	
15	2.00	2.90	3.90	3.55	2.45	1.20	1.00	2.00	.75	3.08	1.3	
16	2.70	2.90	3.70	3.50	2.50	1.20	.99	6.50	.70	2.35	1.3	
17	2.70	3.10	5.20	3.40	2.20	9.00	.90	3.20	.65	2.00	1.4	
18	2.50	8.00	8.00	3.20	2.95	9.50	.80	2.00	.65	1.95	5.0	
19	2.45	2.95	6.20	3.20	2.20	9.50	.75	1.50	.60	1.85	9.0	
20	2.40	2.65	5.30	3.10	3.00	8.00	.75	1.20	.60	1.65	8.0	
21	2.35	3.00	4.50	3.00	4.15	2.60	.75	3.70	.60	1.50	5.0	
22	9.00	5.00	4.00	3.00	2.30	2.00	1.00	1.50	.80	1.45	2.8	
23	10.00	10.00	3.90	2.90	2.30	1.90	1.00	1.60	1.90	1.30	2.5	
24	9.00	12.00	3.65	2.85	2.00	1.60	1.40	1.30	1.90	1.25	2.35	
25	4.50	15.00	3.55	2.75	2.10	3.00	.90	1.10	1.20	1.35	3.0	
26	4.00	18.00	3.45	2.75	2.30	3.00	.80	1.00	1.00	1.35	9.0	
27	5.50	20.00	3.25	2.70	2.30	3.00	.85	1.00	2.35	1.25	9.0	
28	8.20	24.00	3.15	2.65	2.00	3.00	.75	.70	1.60	1.15	10.0	
29	8.00	.....	3.50	2.60	2.00	2.00	.65	.60	1.60	7.25	7.0	
30	5.75	.....	5.50	3.50	1.70	3.55	1.20	.60	1.10	8.20	3.35	
31	5.90	.....	5.55	.....	1.65	.....	2.20	.60	.....	3.80	.....	

Rating table for Appomattox River at Mattoax, Va., for 1902.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.4	140	4.2	875	7.8	2,288	16.5	6,675
.8	180	4.4	935	8.0	2,380	17.0	6,965
1.0	200	4.6	995	8.5	2,615	17.5	7,255
1.2	224	4.8	1,065	9.0	2,850	18.0	7,555
1.4	251	5.0	1,135	9.5	3,090	18.5	7,855
1.6	282	5.2	1,205	10.0	3,330	19.0	8,170
1.8	316	5.4	1,275	10.5	3,575	19.5	8,485
2.0	350	5.6	1,345	11.0	3,820	20.0	8,815
2.2	390	5.8	1,415	11.5	4,065	20.5	9,145
2.4	430	6.0	1,490	12.0	4,310	21.0	9,490
2.6	473	6.2	1,576	12.5	4,555	21.5	9,835
2.8	519	6.4	1,662	13.0	4,805	22.0	10,195
3.0	565	6.6	1,748	13.5	5,055	22.5	10,555
3.2	615	6.8	1,834	14.0	5,315	23.0	10,930
3.4	665	7.0	1,920	14.5	5,575	24.0	11,695
3.6	715	7.2	2,012	15.0	5,845		
3.8	765	7.4	2,104	15.5	6,115		
4.0	815	7.6	2,196	16.0	6,395		

Estimated monthly discharge of Appomattox River at Mattoax, Va.

[Drainage area, 745 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1902.					
January	10,195	350	1,684	2.26	2.61
February	11,695	484	2,501	3.36	3.50
March	9,490	602	2,014	2.70	3.11
April	3,820	473	1,004	1.35	1.51
May	1,920	290	601	.81	.93
June	3,090	224	668	.90	1.00
July	640	165	277	.37	.43
August	1,705	160	437	.59	.68
September	690	150	246	.33	.37
October	4,065	212	934	1.25	1.44
November	3,330	251	877	1.18	1.32
December	4,855	400	1,637	2.20	2.54
The year	11,695	150	1,073	1.44	19.44

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